

THE UTILITY OF THE  
PYROMETER ON  
CARBURETTED WATER  
GAS MACHINES

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## THE UTILITY OF THE PYROMETER ON CARBURETTED WATER GAS MACHINES\*

*By* CHESTER S. HEATH, *Chicago*

The pyrometer is an instrument which is used to measure comparatively high temperatures, such as would be found in blast furnaces, muffle furnaces or retorts, reverberatory furnaces, and in gas machines. In connection with the first three furnaces mentioned, the blast, muffle, and reverberatory, the pyrometer has been used for some time as an aid to the daily operations, and considerable literature has been written about the pyrometer as used with those furnaces, but the use of the pyrometer in the daily operation of gas machines is hardly past the experimental stage, and practically no literature can be found upon the subject. It is, therefore, the intention of the author to set forth some of the observations made, and results obtained, in the daily use of the pyrometer since it was first installed in a gas machine under his supervision; namely, since September 1908.

This article is not intended to be a purely scientific treatise on the subject to be discussed, but one which will be of practical value to the man in charge of a gas plant, essaying to give a clearer understanding of the conditions, and temperatures found in water gas machines, and to disclose such improvements in the operations of the machines as have been the result of the use of the pyrometers. Consequently, in various parts of the paper commercial terms which are readily understood by men in the gas industry may be used instead of a scientific expression of the same conditions.

For reasons which will be apparent in the discussion of this paper, the class of pyrometers most adaptable to our use is the thermo-electric pyrometer, consisting of a thermo-electric couple

\*Photographs taken by George C. Elmberger;

Diagrams of three types of gas machines by T. W. Goodrich.

or fire-end, a temperature indicator and a temperature recorder connected in parallel to the fire-end by copper wire. The principle upon which the electric pyrometers are built depends upon the fact that when two wires of unlike metallic composition having differing electrical conductivity are welded or twisted together at one end and this end is subjected to heat, a difference in potential is set up in the cool ends of this thermo-electric couple. If these ends are connected together by copper wire an electric current is established through the wire, traveling from the point of high potential to the point of low potential, and when a milli-voltmeter (or galvanometer) is placed in the circuit the strength of the current may be accurately measured. When two instruments are placed in parallel so as to read the temperature from a single fire-end of thermo-electric couple, one instrument (for example, the indicator used by the gas maker) is a milli-voltmeter and the other instrument (such as the recorder in the superintendent's office) is a galvanometer.

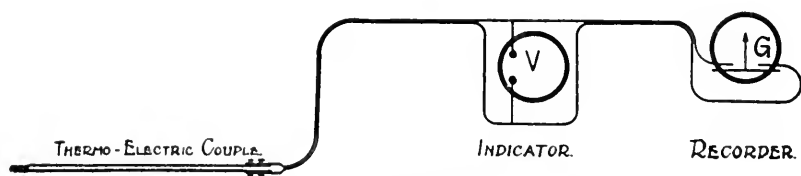


DIAGRAM OF PYROMETER.

The strength of the current is proportional to the difference in potential set up in the thermo-electric couple and this difference in potential is proportional to the difference in temperature of the hot and cool ends of the couple. Hence, if the cool ends are kept at a constant temperature the readings on the milli-voltmeter and on the galvanometer will be directly proportional to the temperature of the twisted or welded ends. By proper calibration of the two instruments they may be adjusted to read directly the temperature of the hot junction in degrees Fahrenheit or in degrees Centigrade. It is readily seen that the two wires of the fire-end must be insulated from each other to avoid the danger of partial short circuits due to the difference in potential of any portion of the wires which may be cooler than the welded end. The wires of the thermo-electric couple may be made of various metals depending



largely upon the temperatures to which the couple is to be subjected although as a rule one wire is a single metal and the other is an alloy, such as the platinum and platinum-rhodium couple, the iron and copper-manganese couple or the nickel and nickel-chromium couple. The composition of the gas which surrounds the couple has no influence on the indications of the instruments.

The purpose of the pyrometer in the gas machine is primarily to aid the operator in maintaining uniform temperatures ("heats," according to work's parlance) in the various parts of the machine, at the best temperature for making gas of a desired quality; and secondarily, to keep the general superintendent in touch with the operations of each gas maker on both day and night shifts, as shown by the recorder instrument. The object of this paper may be divided into the following classification:—

1. A determination of
  - a. the most efficient temperature to maintain in manufacturing gas of certain quality.
  - b. the effects of carrying other temperatures.
  - c. the range of temperature that is practicable.
  - d. the limitation of theoretic operation by practical difficulties.
2. Illustration of a method of installation of the pyrometer, so that:
  - a. the superintendent while at his desk in the office may always be in touch with the operations of the gas makers.
  - b. the gas makers may readily watch and control the temperatures in various parts of the machine without leaving the operating valves.
3. A determination of the exact temperature in various parts of the machine while in operation in order that we may have a clearer and more accurate understanding of gas machines.
4. An exemplification of features other than the temperatures of operation, whereby the use of a pyrometer has been of benefit in practice.
5. A discussion of the results obtained and of subsequent improved methods of operating the machine which are primarily due to the aid of pyrometers, in such a manner as will be of interest to the average gas man and will aid him in an understanding of machine operations even if he has no intention of using a pyrometer in his plant.

Before discussing the question of temperatures most suitable for the proper and practical operation of gas machines it may be well to describe a few of the ordinary conditions and troubles encountered before the pyrometer was used. At that time the gas maker was required to go down stairs to the floor below the charging floor and walk around his machine (in the case of type No. 2) or to climb up two flights of stairs and walk around his machine (in case of type No. 1) to sight-holes where he might look into the machine and judge whether the brick were too hot or too cold; or, whether the oil spray in the carburetter was working properly or was causing "dark streaks" through the checker brick. It will be readily seen that the operator could not make this trip very often and attend to other necessary work, such as proper adjustment of primary and secondary blast valves, regulations of steam pressure and of oil admitted to the carburetter within the limited time of these operations. Very often it is impossible for the foreman to watch the temperatures in each machine, as he has many other duties which demand his constant attention. It may be noted that in stating the fact that the gas maker would judge the temperature of the brick the word "judge" was selected, for the eye may be deceived in many ways as to the true temperature of brick surrounded by a gas or gaseous vapor and judgment at its best, we all know, is subjected to the personal equation. If one authority would say a machine was too cold and another would say it was too hot, what should an ordinary gas maker do? There is no personal equation to a pyrometer and as previously stated, it indicates the true temperature irrespective of the surrounding gases.

Before the instruments were installed the life of the machine was from 800 to 1000 hours, due to the formation of lamp-black in the superheater. The checker brick would often become so thickly coated with carbon that the resultant back pressure would decrease the amount of gas made to a marked degree, often the machine had to be shut down for two days at a time in order to burn out some of the carbon by admitting air through the checkering doors. When the machine was let down for repairs the bricks would be covered with carbon and ash, burned so hard as to require a pick or sledge and bar at times to remove them from the upper part of the superheater. Strict attention to the temperatures carried in the operating machine and every other known precaution were employed to overcome these conditions without any results until the pyrometer told the story. The condition that the pyrometer revealed will be discussed and illustrated in the following paragraphs.

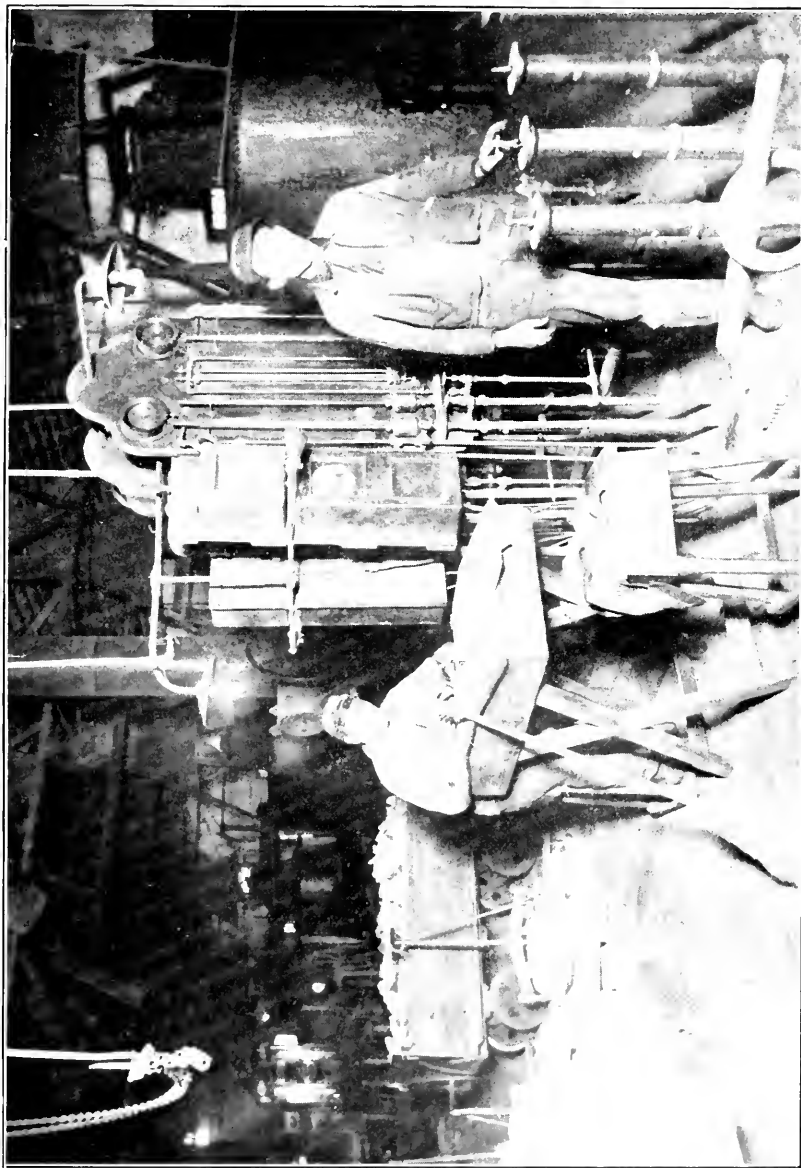


PLATE I—Pyrometer Indicators in Generator House.

(Instruments are located in the center of the picture between the gas maker's desk and the gauge board—the upper one for the superheater and the lower for carburetter.)



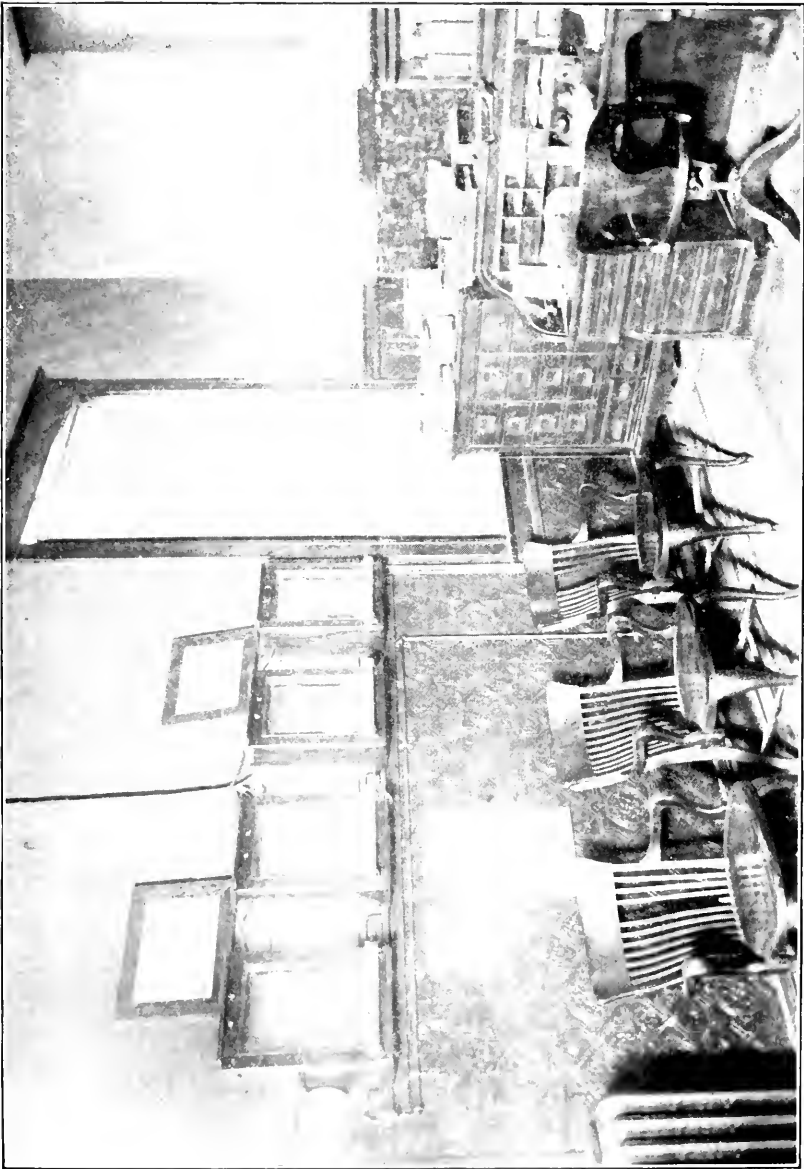
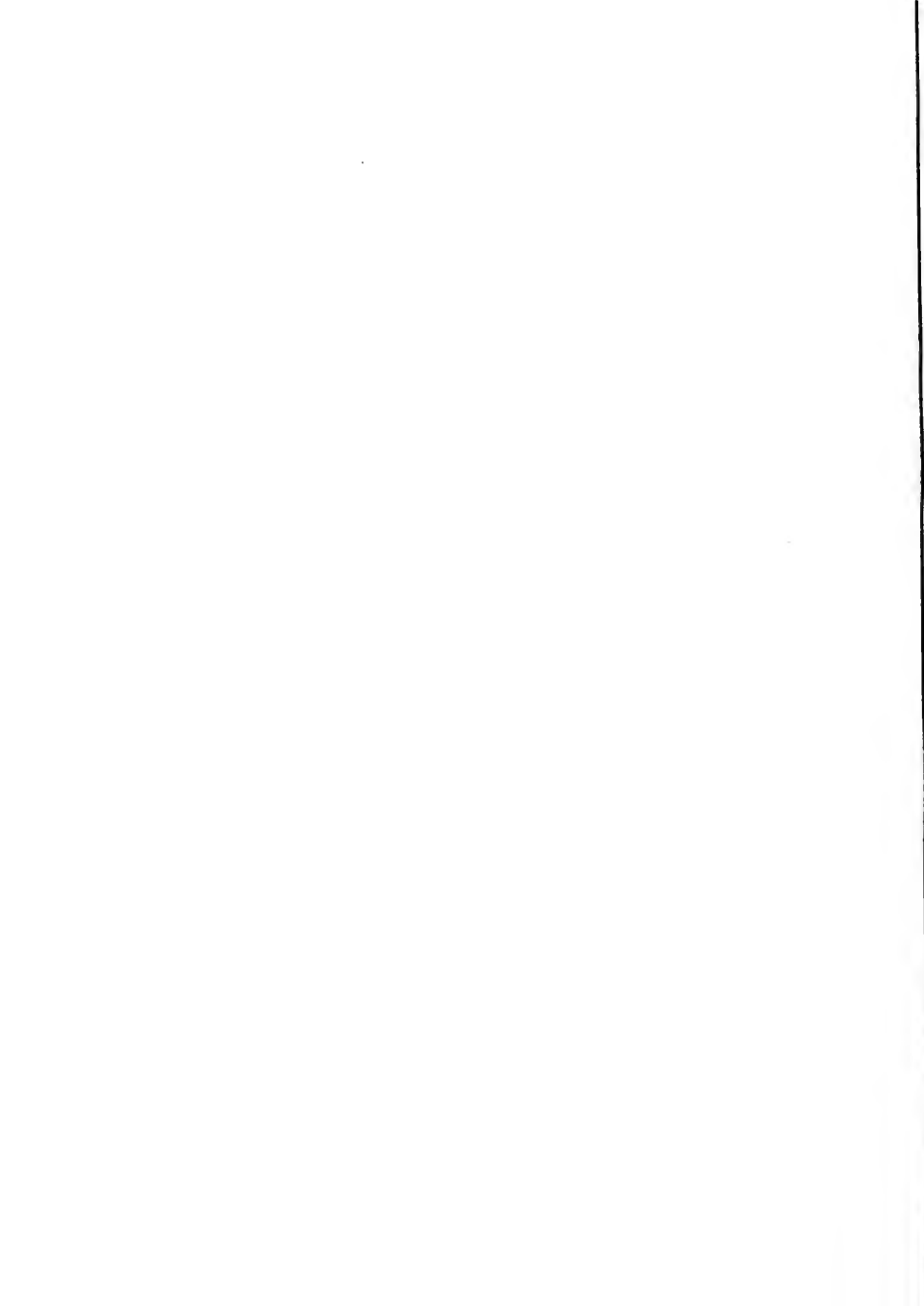


PLATE II—Four Pyrometer Recorders in Office of Gas Works.

(The instruments are located on the wall beside the superintendent's desk fully 600 feet away from the gas machines in the generator house.



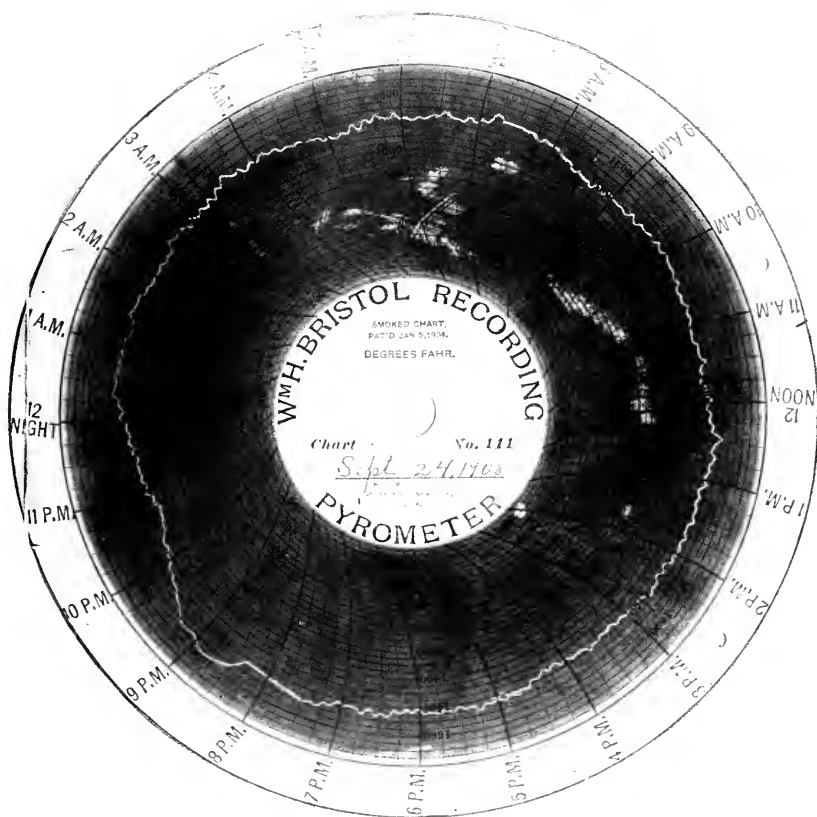
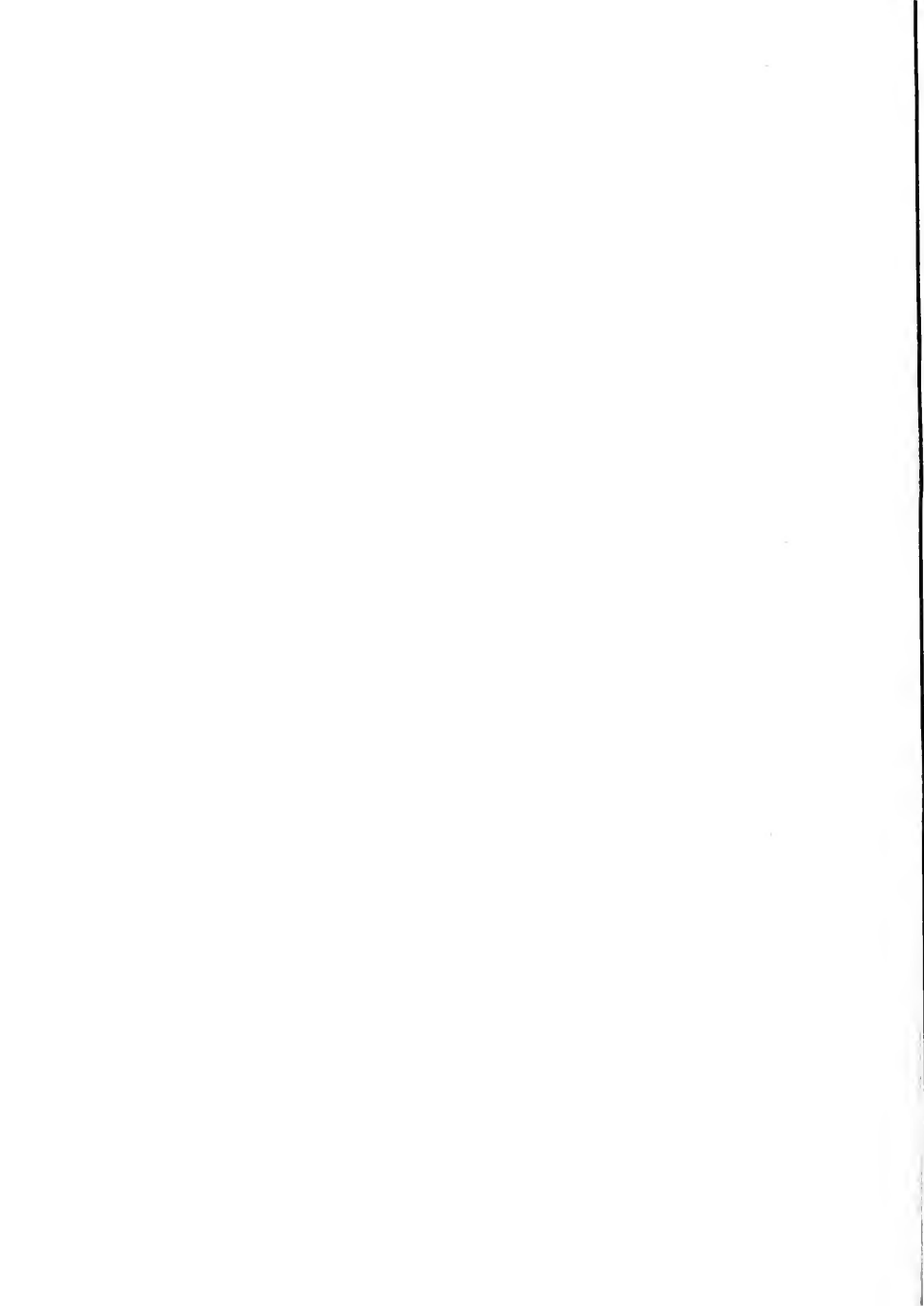


PLATE III.





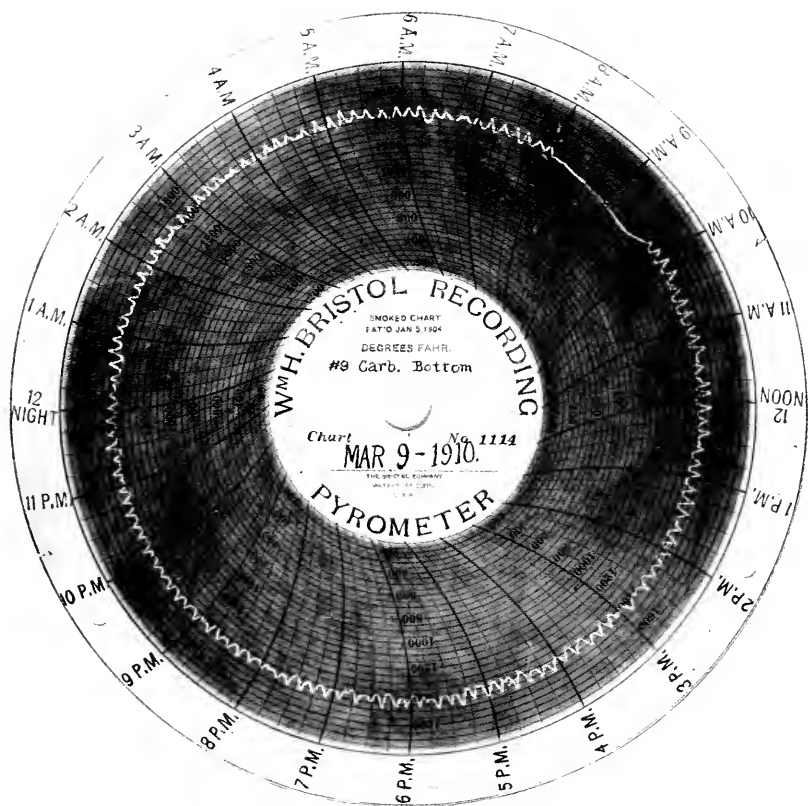
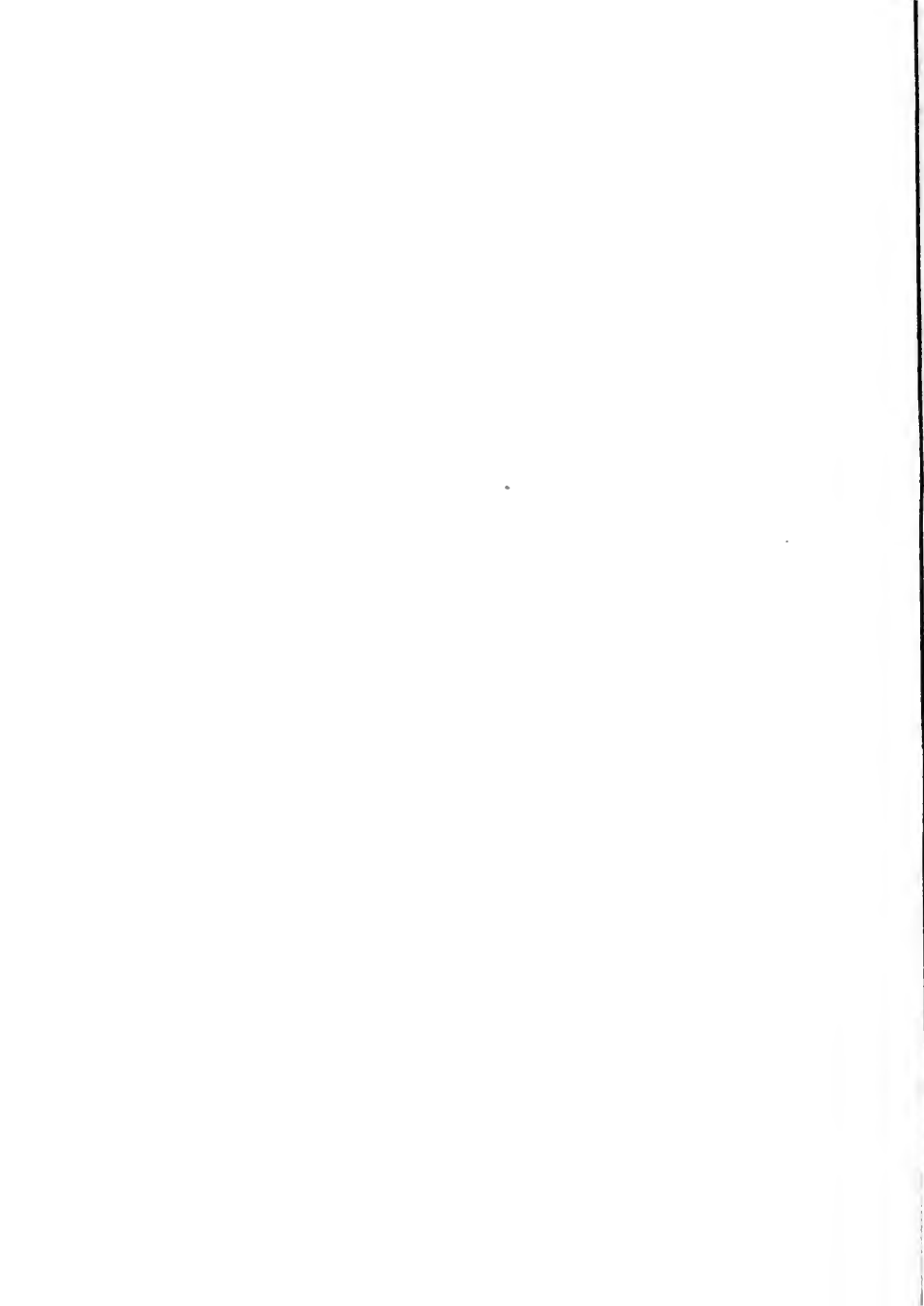


PLATE IV.



Upon the introduction of pyrometry in the gas industry in Chicago we found that there were three points to be considered in placing the instrument; first, the best position of the fire-ends in the machine; second, the most accessible position of the indicating instrument for the gas maker; and third, the most desirable position of the recording instrument for the superintendent. It was necessary to have two sets of fire-ends in each machine to control the temperatures properly, one in the carburetter and one in the superheater. The carburetter temperature was taken from the lower part of the carburetter while the superheater was taken from the top, which at that time was considered to be, and was, usually, the hottest part of the machine. The two indicator instruments (one for the carburetter and one for the superheater) were placed directly in front of the gas maker's stool and beside the gauge board, as is illustrated in Plate No. 1, and connected to the fire-ends by copper leads 90 feet in length. The recorder instruments for the various machines were placed along the wall in the superintendent's office, as illustrated in Plate No. 2, and connected in parallel with the indicator instrument to the fire-ends by copper leads 600 feet in length, which fact illustrates the adaptability of the thermo-electric pyrometer. By this arrangement the gas maker can watch the temperature rise or fall at all times without leaving his operating valves. He can therefore regulate his primary, secondary and superheater blast valves as conditions demand, instead of operating by a "rule of thumb" method. The superintendent by simply turning in his chair is in constant touch with the generator house. He can tell at a glance which machine is down for cleaning; how long each has taken to clean; how the cleaning time compares with the record of previous days; what temperature is carried by each machine in operation during the present run and for any previous run; which machines may not be in operation and how long they have been shut down; what temperatures were carried during the night shift; and how long a machine has been down for repair work. The recording chart may prove of value in case of dispute as to the exact time an accident had happened on a machine and the length of time required to make repairs, especially if the occurrence was during the night shift.

When the first instrument was installed at Pitney Court Station the temperature at the bottom of the carburetter was not carried as uniformly as we now carry the temperatures. (See Plate No. 3 and Plate No. 4 for comparison.) It may be noted that with the pyrometer newly installed and before the gas maker knew its purpose the variation in temperatures while the machine was in

operation was not excessive, being less than 100 degrees for the 24 hours excepting for the period just after cleaning when the temperature had to be carried low in the carburetter (by blasting more on the fire and using less secondary blast) until the superheater was cooled down to a cherry red color desired. We observe by means of the superheater indicator that the temperature of the upper courses always increase to 1600 or 1800 degrees during the cleaning or clinkering time, an increase of as high as 400 degrees above operating temperatures. This was also noted in the carburetter (as shown by records, Plate No. 5) although not always to such a marked degree as shown in the superheater. When you are informed that it requires from 6 to 10 hours to bring this excessive temperature down\* to the desired 1350 degrees in the superheater (although the carburetter temperature can be reduced in about an hour) you can readily understand that this is the period during which coke is being wasted and lamp black formed with the resulting loss of candle power in the gas manufactured.

Improvements in the methods of handling the machine were then devised to prevent this increase of temperature in the brick work during clinkering. The gas machine had been allowed to stand open to the circulation of a natural draft of air through the carburetter and superheater and out the stack. This air would burn any fine coke dust or lampblack which may have lodged on the brick during the previous period of gas making and thereby raise the temperature of the brick far above good operating conditions. To overcome this trouble the circulation of air through the machine was stopped, on some of the machines by closing down the purge cap and on others by closing the up and down run valves in the hydrogen pipe between the generator and carburetter, according to local conditions. (Note. Before starting to blast through the machine after clinkering a small amount of steam was turned on to cause a circulation through the machine and prevent small explosions of the gases which may have formed.) By this operation an even temperature was maintained in both carburetter and superheater while the stokers were removing the clinkers, but as soon as the blast was put on the generator the excess air for the first few minutes while the fire was still cold would cause an increase in temperature in the machine for the same reasons. This

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\*By means of careful manipulation of the blast valves, such as increased primary blast (because the temperature of the fire is low after cleaning) and decreased, or often no secondary blast with a large loss of heat and waste of coke from excess gases burning at the stack.

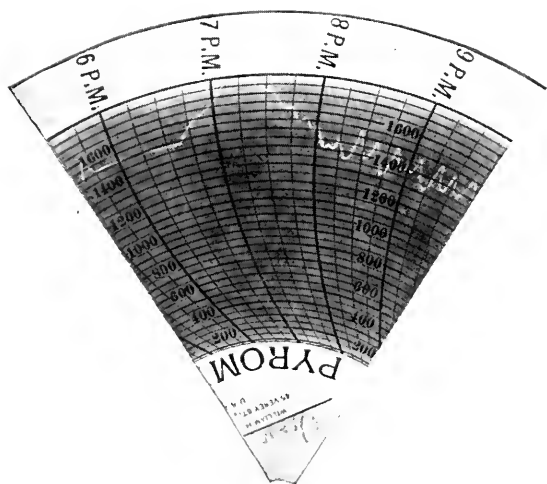
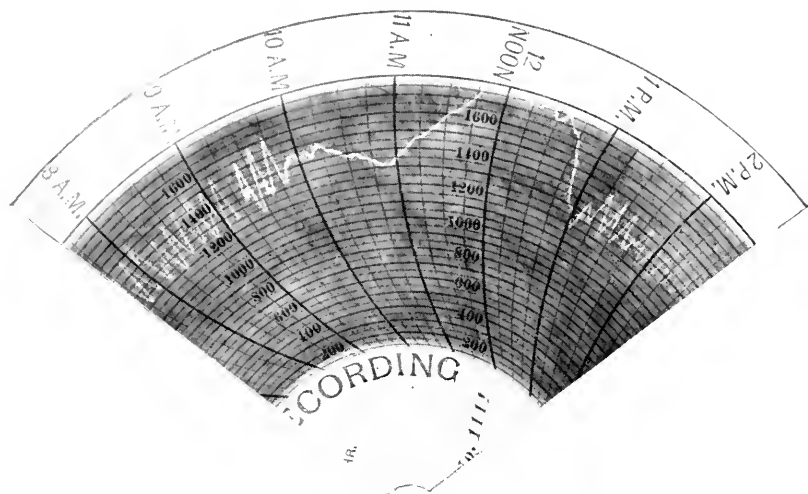


PLATE V.



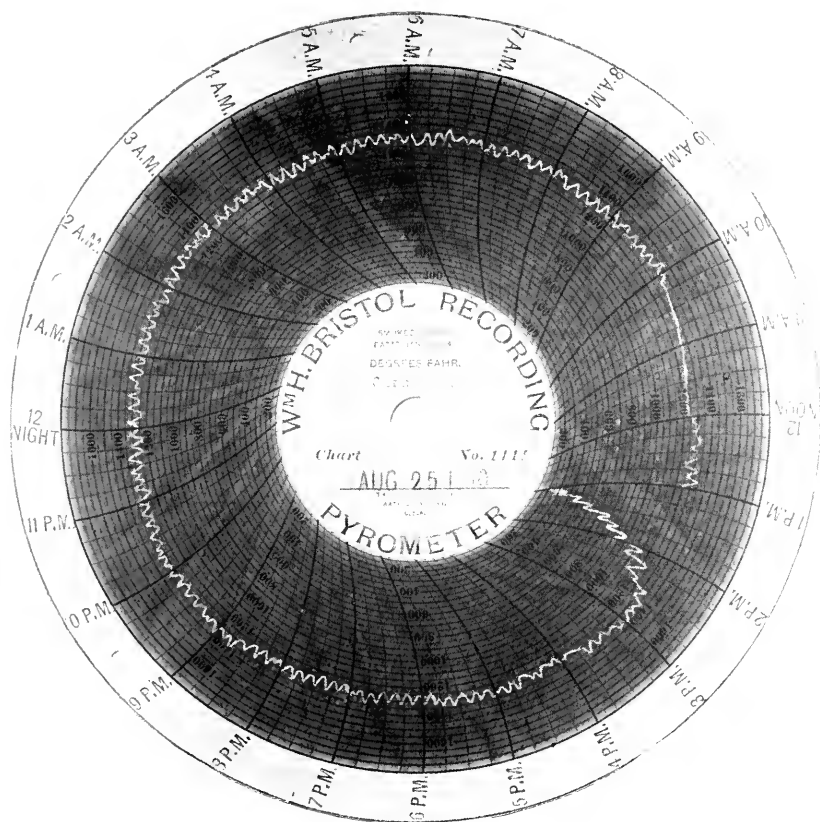
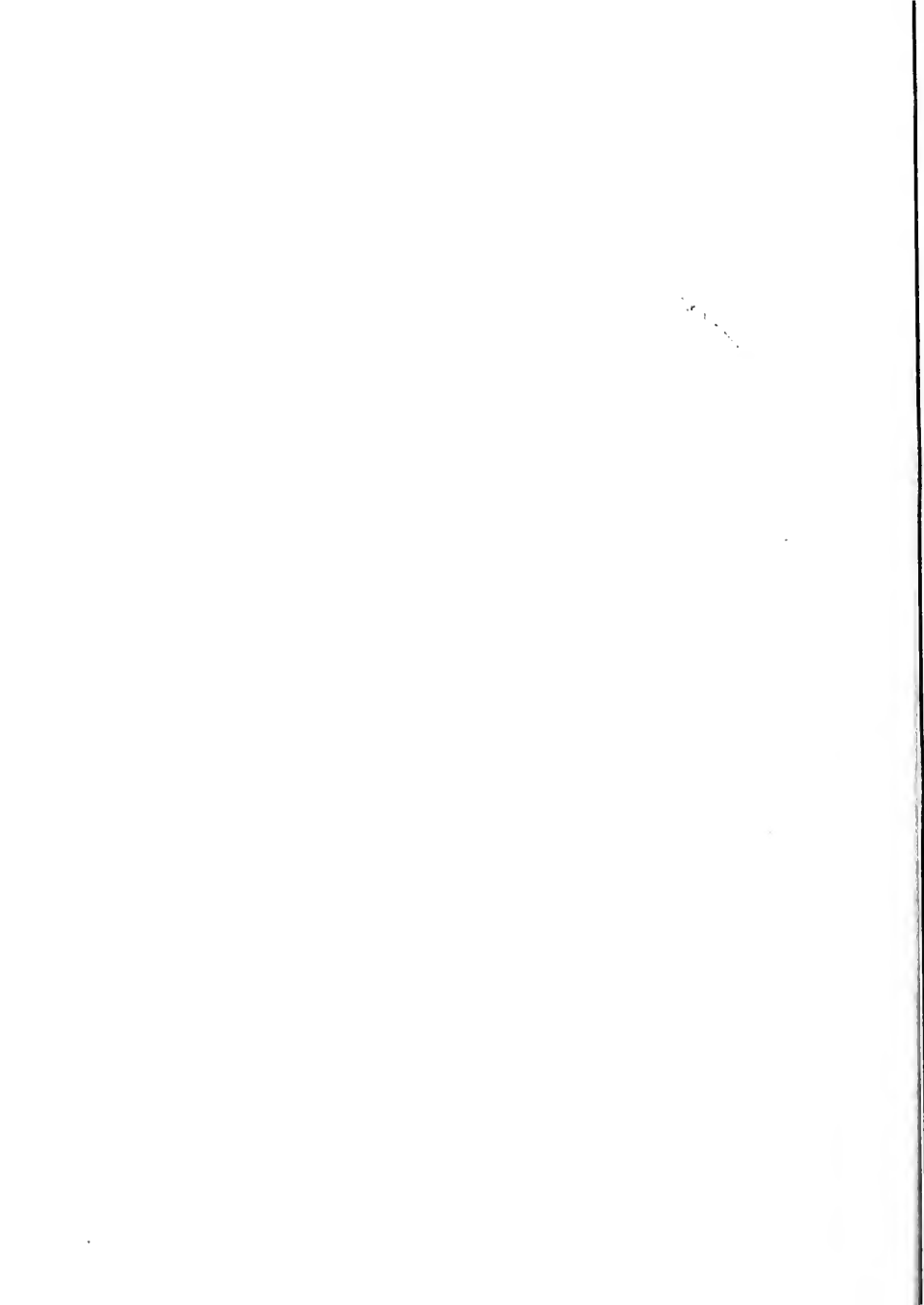


PLATE XIV.





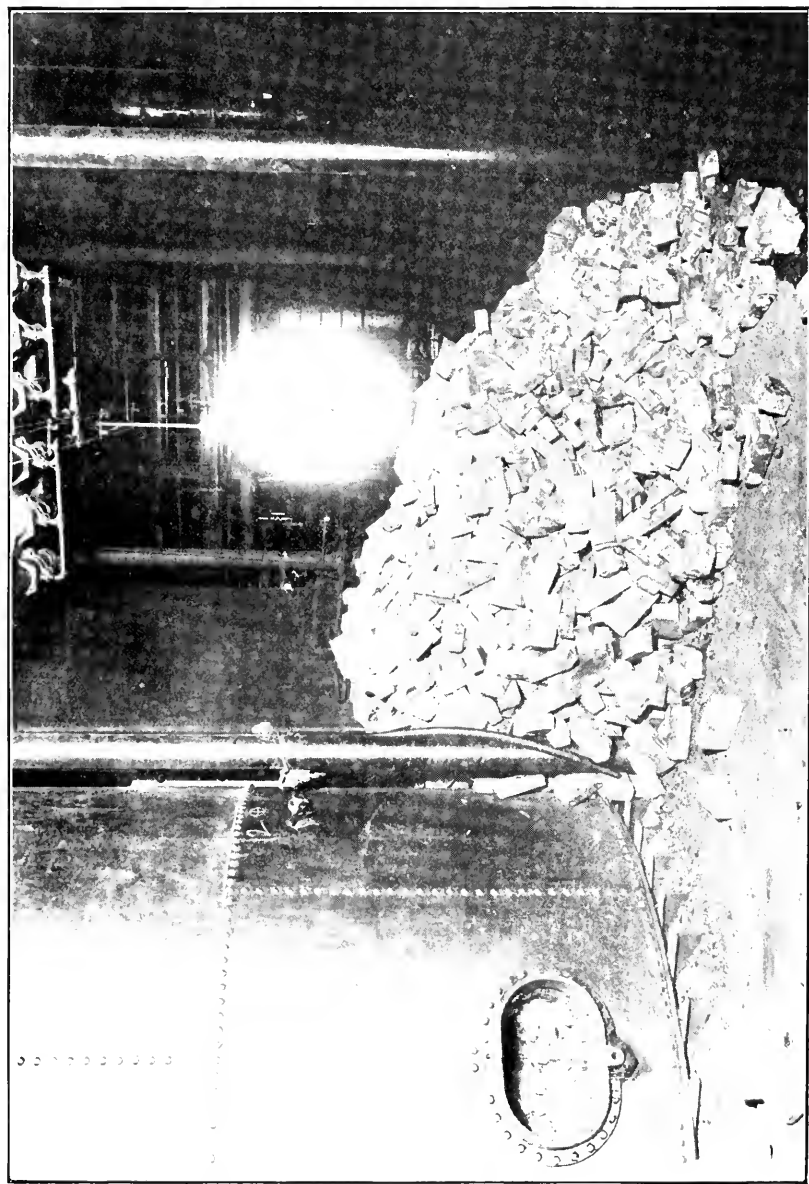
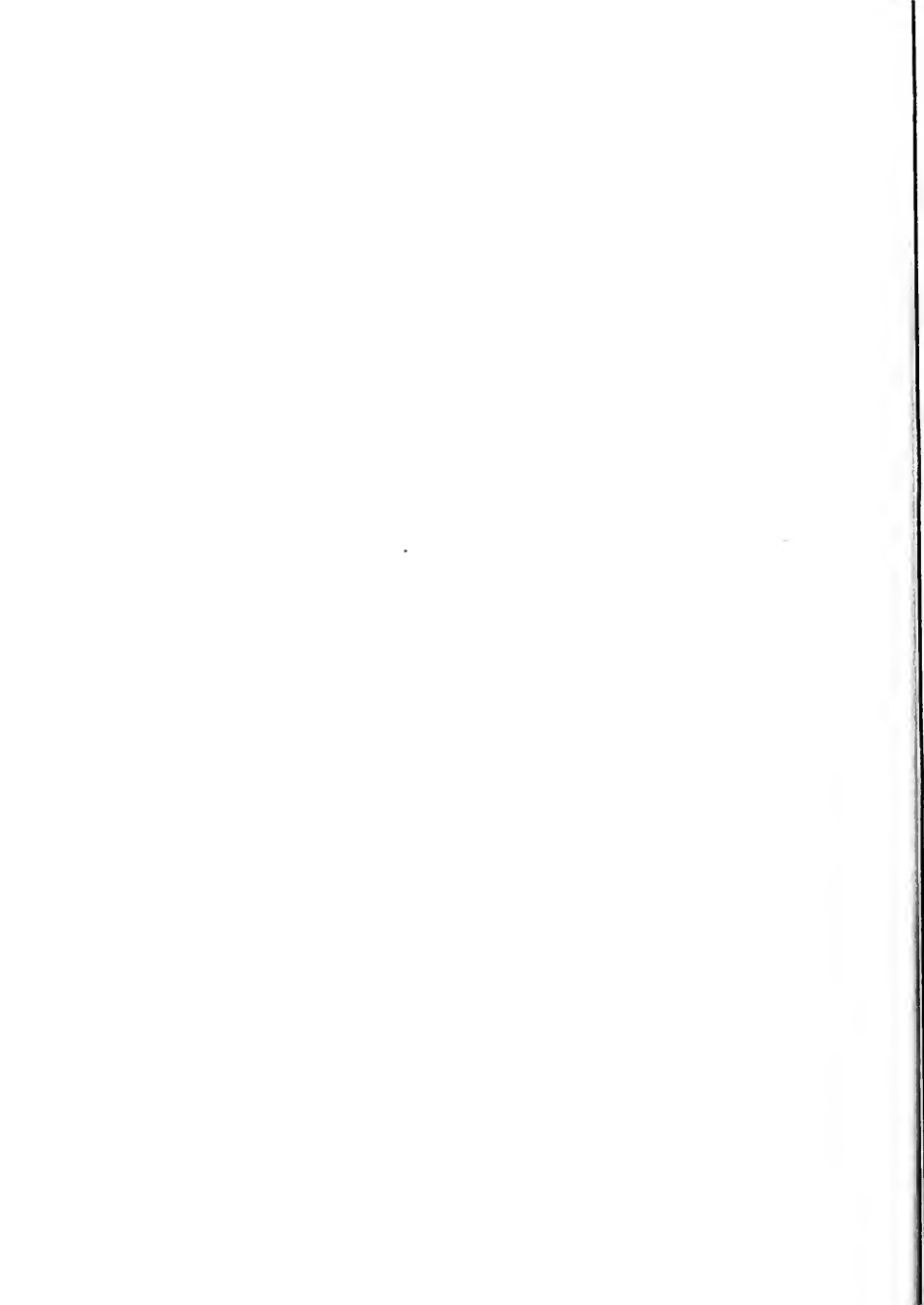


PLATE VI—Checker Brick from 11 Foot Machine Using Pyrometers.



CHECKER BRICK FROM GAS MACHINE USING PYROMETERS.



PLATE VII—Note the freedom of brick from lamp black. The top course in carburetter shows some burned oil, which is difficult to prevent on the top course; other bricks show a thin layer of reddish dust; the last two bricks have been used twice as the upper half of the superheater is always rechecked with old brick. These brick have been taken from an 11 foot gas machine after 2400 hours' use in actual gas making time.



trouble was not so bad as it only took about an hour or two to bring the superheater temperatures down to operating requirements, but since the best operating conditions are none too good from the very first minute that gas is being made and sent into the holders, it was decided to blast on the fires until they were hot enough to make gas without allowing the excess air or comparatively cool blast gases to pass through the carburetter and superheater. To accomplish this the charging doors on the top of the generator were opened and the blast gases allowed to pass through until considerable flame showed above the top of the coke. The primary blast valve was then closed, the up-run valve in the hydrogen pipe or the purge cap as the case may be was opened, the charging doors were closed, a small amount of steam turned on for a moment, the primary blast valve finally raised, and the entire machine was then in the best operating conditions before a cubic foot of gas was sent into the holders. With these changes in the operation we find that the temperature in both carburetter and superheater is almost constant during clinkering excepting for the slight loss due to radiation. (See Plate No. 4—cleaning time from 8:05 A. M. to 9:45 A. M.; also, Plate No. 14—cleaning time from 10:10 A. M. to 12:00 M.

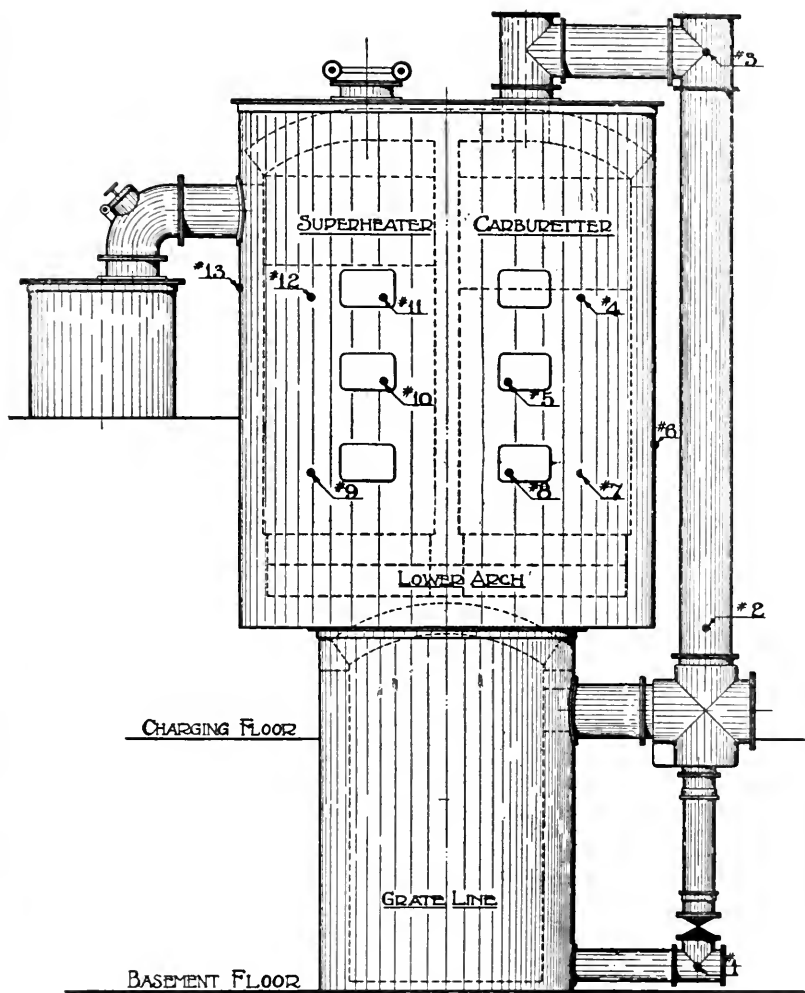
By these improvements in the methods of handling the machine (which you will note can hardly be called a change in operation during gas manufacture, but rather was a change in the conditions of the machine while idle and when no one would think of watching the temperatures of checker brick) the life of the brick has been increased about 100% and in some cases as high as 175% and the brick are now quite free from lamp black when the machine is let down for repairs and recheckering. There is no time lost for gas making as there is no necessity of burning out any lamp black in the machine. Plate No. 6 shows the clear cut outlines of the brick as removed from an 11-foot water gas machine. In the foreground a portion of the brick from the superheater is shown. The condition of the brick is better illustrated in Plate No. 7. The bricks are arranged in the direction of the travel of gas through the machine, starting at the left side of the Plate. The first was taken from the top course of brick in the carburetter, the second from the middle course, the third from the bottom course, the fourth from the bottom course in the superheater, the fifth from the middle course and the sixth from the top course. The fifth and sixth bricks have been in the gas machine twice, as the upper half of the superheater is always checkered with old brick. The first brick shows that some of the lighter fractions of the gas

oil have been burned on the brick, which fact is noticeable only on the first and sometimes second course. This trouble is overcome in a large measure by delaying the admission of oil for a fraction of a minute after the steam has been turned on, thereby reducing the temperature of the upper courses so that the cold oil will not be over-cracked, or in work's parlance, taking the "sharp heat" off the top courses. When the machine is shut down for repairs the brick immediately begin to cool and may easily be removed by a long handled hook or by hand when sufficiently cold, whereas it previously required two or three days to burn out the carbon and three or four more to cool off the bricks which had become almost white hot by the intense combustion of this fine carbon.

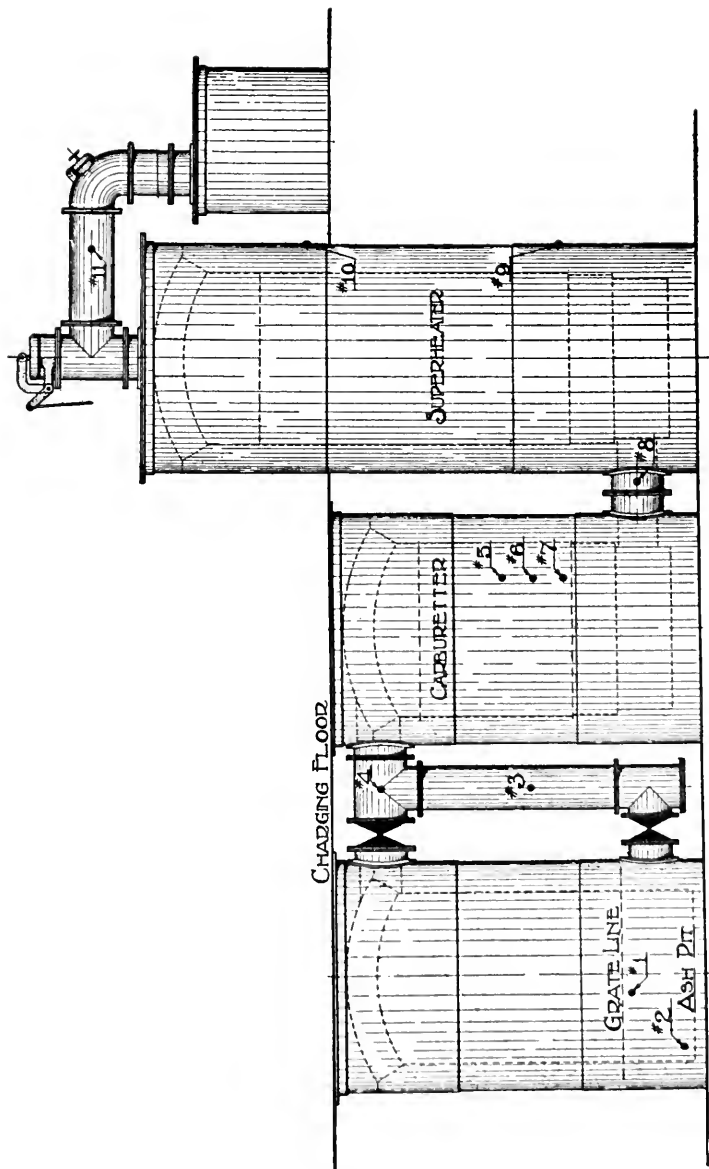
With the carburetter and superheater checkerwork as free and open the day the gas machine was let down for repairs as it was the day it was started, it became necessary to determine in a general way by means of the pyrometer when the life of the brick was exhausted. When the brick are new there is only a slight drop in temperature in the bottom of the carburetter with the addition of a given quantity of oil but as the brick become old the drop in temperature is greater for the same amount of oil used. The following table shows the loss in temperature as indicated by the pyrometer with its fire-ends placed in the middle of the carburetter or nine courses down from the top.

No. Machine	Date when rechecked.	Drop in temperature	
		new brick	old brick
No. 7 Machine	June 1909	150	300
No. 7 Machine	Oct. 1909	200	350
No. 8 Machine	Oct. 1909	250	500
No. 9 Machine	June 1909	250	400
No. 9 Machine	Oct. 1909	125	325
No. 10 Machine	July 1909	175	375
No. 10 Machine	Nov. 1909	200	325

This increased drop in temperature is due in a large measure to the fact that the heat stored in the brick is not as quickly conducted to the surface of the old brick as it is in the new and therefore, more heat is required from the courses farther through the machine to fix the oil vapors as gases when the brick are old.

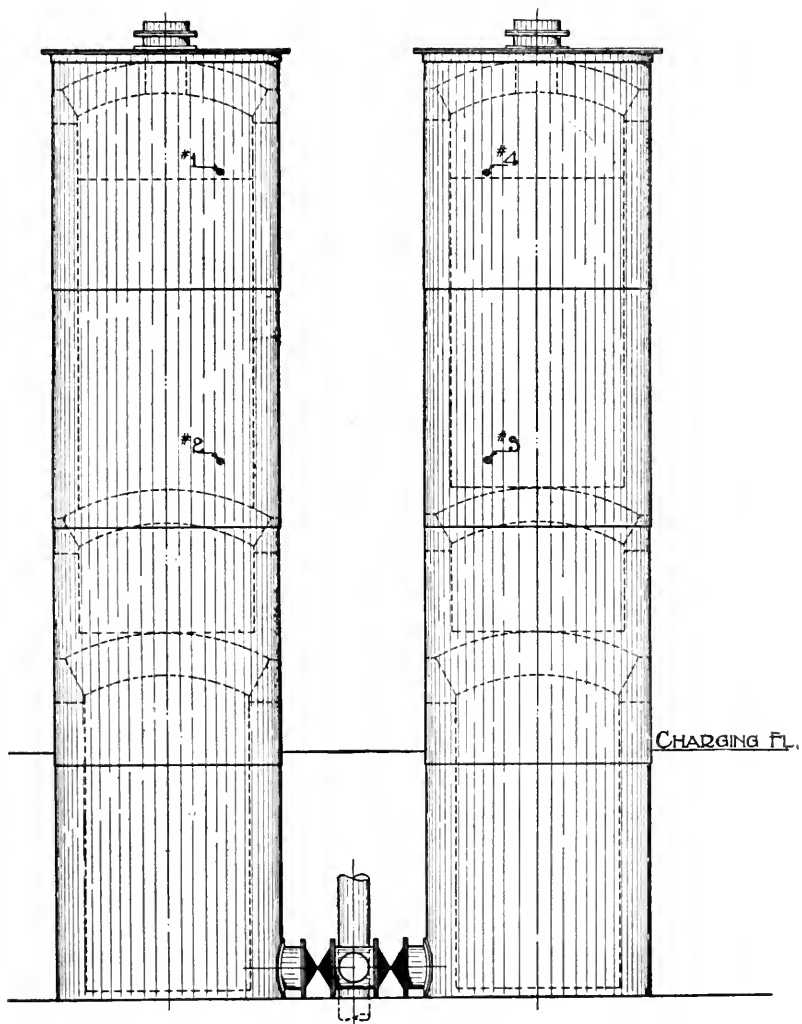


TYPE N° 1



TYPE No 2





TYPE №3

It will be noted in comparing the following table with the preceding that although the drop in temperature of the brick is somewhat less in the bottom of the carburetter or 17 courses from the oil spray than it is nine courses from the oil spray when the brick are old, yet the drop is very slight in the bottom course when the brick are new.

No. Machine	Date when rechecked.	Drop in temperature	
		new brick	old brick
No. 7 Machine	Oct. 1909	100	250
No. 8 Machine	Apr. 1909	75	275
No. 8 Machine	Oct. 1909	75	300
No. 9 Machine	June 1909	100	200
No. 9 Machine	Jan. 1910	75	150

This increase drop in temperature upon the addition of the same quantity of oil per run is a fair indication that the machine needs new checker brick; as the gas work's foreman would say, the machine "won't hold her heats."

In order to obtain information regarding the distribution of heat through various types of gas machines and the variation in temperature at different points in the machine under operating conditions, I took simultaneous records of the temperatures at given points for 14 consecutive days, noting the changes in operation. The diagram of the three types of carburetted water gas machines give a clear conception of the points at which these continuous records were taken. (See diagram of type 1, 2, 3.) The black areas with their corresponding numbers indicate the position of the fire-ends in each type, numbering from No. 1 on, in the direction of travel of gas through the machine.

In type of gas machine No. 1, records were taken of the temperatures of down-run gases at the base of the hydrogen pipe; of up and down-run gases and blast gases in the hydrogen pipe just above the "Williamson" water-sealed hot valve; of the gases at the top of the hydrogen pipe; of the first course of brick in the carburetter; of the 12th course of brick in the carburetter near the center wall between the carburetter and the superheater; of the 20th course of brick at the farthest point from, and at right angles

to, the center wall; of the 23d course as shown in the diagram; of the 23d course near the center wall; of the 39th course of brick (39th from the oil spray or 8th from the bottom of the superheater); of the 50th course of brick; of the 61st course of brick near the center wall; of the 61st course away from the center wall; of the 62nd course at right angles to the center wall (top of superheater.)

In type of gas machine No. 2 records were taken of the temperatures of down-run gases in the generator 4 inches below the grate bars; in the ash pit; and in the hydrogen pipe as indicated in the diagram; of the temperature of up run, down run and blast gases at the top of the hydrogen pipe near the "Levy" valve; of the 9th course of brick from the oil spray in the carburetter; of the 13th course; of the 17th course; of the gases passing through the connection pipe between the carburetter and superheater; of the 19th course (or first course in superheater;) of the 56th course (or top of superheater;) and of the gas in the take-off pipe.

In type of gas machine No. 3 readings were taken from the top course and bottom course of brick in one shell and the bottom course and top course of the twin shell.

To discuss the results obtained at each of these points in detail would require more time than may well be taken in this meeting, but I shall be pleased to go more fully into the discussion of any results or conclusions in which you may be especially interested.

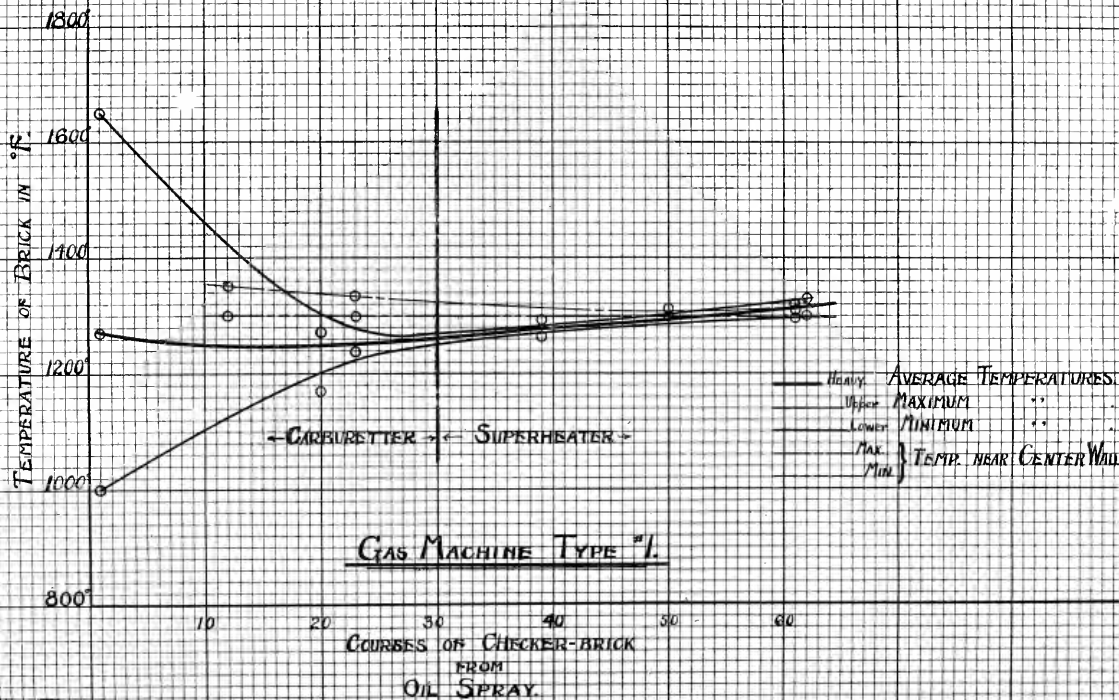
The average temperatures obtained by series of tests on type No. 1 water gas machine may be found in the following table. The first column in the table indicates the point at which the temperature was taken (See diagram type No. 1;) the second column indicates the number of courses of checker brick between each position of the fire-end and the oil spray; the third column indicates the maximum temperature at each point, i. e., the temperature attained after blasting; the fourth indicates the minimum temperature, i. e., at the end of the run; the fifth indicates the loss in temperature at each point upon making gas; and the sixth indicates the average temperature carried at each point.

TABLE NO. 1.

Test Point	Course of Brick	Max.	Min.	Drop.	Average	Remarks
1					625 (1610	Center of 12 in. pipe End of blasting
2					(1360 ( 720	End of up run End of down run
3					(1500 (1220 ( 920	End of blasting End of up run End of down run
4	1	1650	1000	650	1270	
5	12	1350	1300	50	1325	12 in. from wall
6	20	1270	1170	100	1220	
7	23	1300	1240	60	1270	
8	23	1335	1300	35	1320	12 in. from wall
9	39	1295	1265	30	1280	
10	50	1310	1300	10	1305	12 in. from wall
11	61	1320	1320	0	1320	12 in. from wall
12	61	1310	1290	20	1300	
13	62	1330	1300	30	1315	

In this type of gas machine the carburetter and superheater are built side by side within a single shell, separated by a 14-inch center wall of brick extending from the lower arch up to the top of the machine. There are about 31 courses of brick in the carburetter and 34 in the superheater. It will be noted from the above table that the temperatures are quite uniform on both sides of this wall, as shown by tests taken at points 5, 8, 10 and 11, and also that the drop in temperature during the run is very small at all these points. Evidently this wall acts as a reservoir of heat tending to maintain more uniform temperatures throughout the fixing chambers.

The first few courses of brick performed the "heavy duty" of vaporizing and cracking the oils as is strikingly indicated by the plotted curve (see Plate 11.) The cooling effect of the oil on the first course is very marked, being about 650 deg. F., while the drop in temperature at the 23rd course (point 7) in the same relative position as that taken at the first course (point 4) is only 60 deg. F.





The temperatures of the down run gases taken at the base of the hydrogen pipe (point 1) averaged 625 deg. F., due to the cooling action of the grate bars, blast boxes, etc., as shall be discussed more fully with type No. 2. These down run gases are heated to about 700 deg.F. at a point 3 feet above the "Williamson" hot valve (point 2) and to 920 deg. F. at the top of this hydrogen pipe (point 3) the temperature of these gases is increased by the heat stored in the fire-brick lining of the pipe during the blasting period. The temperature of the blast gases depends very largely on the condition of the fire, as we have known in a general way. When a fresh charge of coke is put into the generator the temperature of the blast gases will seldom exceed 1000 deg. F., but as each successive blasting increases the temperature of this upper layer of coke, the gases become hotter until they may reach 1750 to 1800 deg. F., as was found after 3 successive up runs. The down run cools off the top of the fuel bed to such an extent that the temperature of the blast gases averaged 100 deg. F. lower than after the preceding up run, all other conditions being equal. It was found that the average temperature of the blast gases at the end of the blasting period was about 1610 deg. F. at point No. 2 and about 1500 deg. F. at point No. 3, showing a loss of 110 degrees due to radiation from the hydrogen pipe. The temperature of the up run gases at the end of the run averaged 1360 deg. at point No. 2 and 1220 deg. at point No. 3, a loss of 140 deg. due to radiation.

A test was made to determine the effect of radiation from the shell of the machine upon the temperature of the gases in the checkered chamber, and thereby decide what should be the minimum length of the fire-end. The results are shown in the following table:

#### TEMPERATURES

Thickness of shell	At shell	12 in. from shell	15 in. from shell	28 in. from shell	54 in. from shell
18 in.					
18 in.	1230°	1280°	1290°	1300°	1300°

In a gas machine with an 18-in. shell the fire-end should be at least 4 feet long.

The average temperatures obtained by series of tests on type No. 2 water gas machine may be found in the following table:

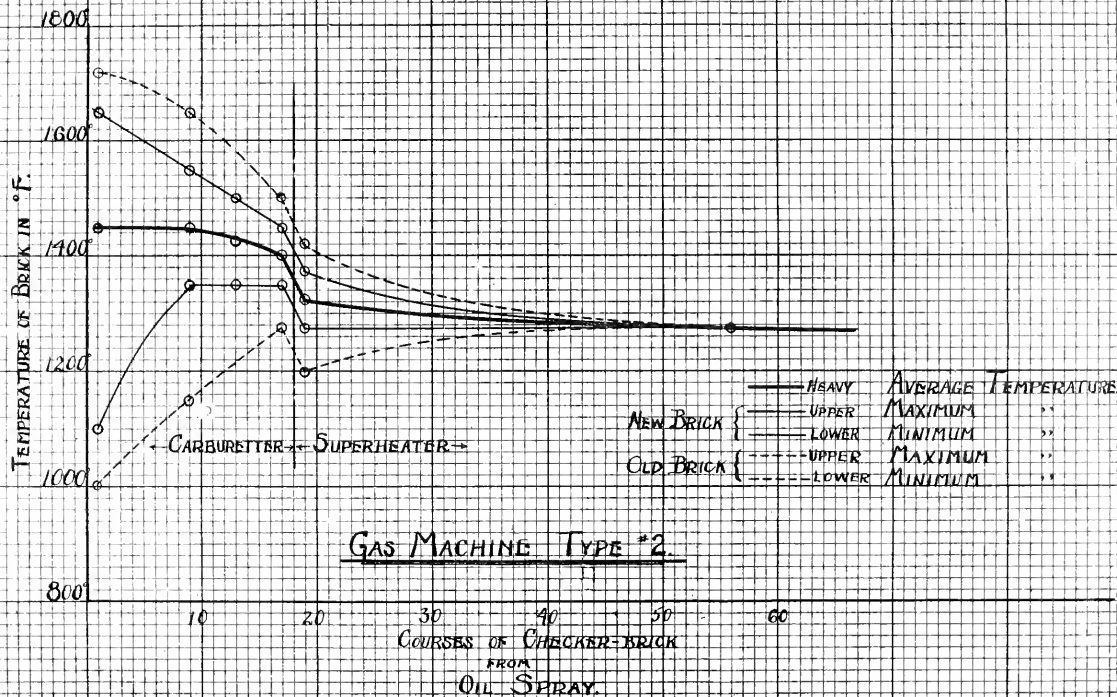
TABLE NO. 2.

Test Point	Course of Brick	Max.	Min.	Drop.	Average	Remarks
1					1025	4 in. below grate bars
2					625	In ash pit
3					475	In hydrogen pipe
4		1750	1400		1575	Up run gases
5	9	1650	1150	500	1400	Old brick
		1550	1350	200	1450	New brick
6	13	1500	1350	150	1425	New brick
7	17	1500	1275	225	1390	Old brick
		1450	1350	100	1400	New brick
8	connection	1600	1150	450	1375	Gas Temp.
	pipe.					
9	19	1550	1300	250	1425	With Superh. blast
		1375	1275	100	1325	Without Superh. blast
10	56	1350	1300	50	1325	With Superh. blast
		1275	1275	0	1275	Without Superh. blast
11					1225	In take-off pipe

In this type of gas machine the carburetter and superheater are in two separate shells connected at the bottom by a 24-inch pipe lined with fire brick. (See Type No. 2.) The curve plotted from the above table (Plate No. 12) shows very clearly that the top nine courses of brick perform the "heavy duty" in cracking the oils; that the average temperature of the brick is lower the farther the course is from the point at which the oil enters; that the variation in temperature during each run becomes less as the distance from the source of oil increases; that the variation at the bottom of the superheater is about the same as at the bottom of the carburetter (excepting at such times as the gas maker uses the superheater blast for one or more runs when the variation is about 250 degrees. 1.\* The loss in temperature in passing through the false

1.\* Note.—When the superheater blast valve is opened wide the velocity of the air evidently drives the zone of combustion higher than No. 9 hole as the temperature remains about constant for the first part of the blast, while the temperature at No. 10 hole rises about 50 degrees. Toward the end of the blast when the Carbon Monoxide in the blast gases increases, the zone of combustion is brought lower and the temperature at No. 9 increases about the usual amount (100 deg.) If the superheater blast is opened a small amount at first and increased as much as may be necessary during the latter portion of the blasting, the temperature of the brick at point No. 9 increases about 250 degrees, while at No. 10 it increases only 25 deg., indicating that the zone of combustion is lower in the superheater.







bottoms of the carburetter and superheater and the 24-in. connecting pipe is clearly shown on the curve. The temperature at the top of the superheater (point No. 10) recorded almost a perfect circle. In the take-off pipe with the fire-end in the cross above the wash-box (point 11) we find that during the run the temperature of the gas averages 1225 deg. when the temperature at point 10 is 1275 deg. F.

It is well at this point of the discussion of the temperatures of the brick in the two types of water gas machines to compare the character of the two curves. (Plate No. 11 and Plate No. 12.) We find that in type No. 1 machine the oil has been completely "cracked" before it leaves the carburetter and the superheater performs its true function of fixing the gaseous hydrocarbons. In type No. 2 machine the curves indicate very clearly that the oil has not been fully "cracked" in the carburetter; that a large portion of the work must be completed in the superheater, in addition to the "fixing" function of that chamber; and that these partially decomposed hydrocarbons are subjected to a sudden cooling of about 100 degrees F. in passing through the 24-inch pipe connecting the carburetter and superheater (which condition is not found in type No. 1.) We must therefore conclude that type No. 1 is a much better proportioned machine than type No. 2.

A short description of the test on the temperatures of the down run gases before entering the carburetter may be of interest. The fire-ends were especially prepared to secure the temperatures of the gases quickly and accurately. A half inch iron pipe four inches shorter than the fire-end was used as a jacket to protect and support the long wires. The hot junction extended four inches beyond the open end of this half inch pipe so as to come in direct contact with the down run gases, while the cold end was held in a stuffing box packed with asbestos at the outer end of the half inch pipe. Three fire-ends, prepared in this manner, were placed in the bottom of the generator about 4 inches below the grate bars (point No. 1); in the ash pit under the blast boxes (point No. 2); and in the hydrogen pipe between the generator and the carburetter (point No. 3); the results of this test (see Table No. 2) indicate much lower temperatures of the down run gases than was anticipated. The clinker and grate bars, cooled by the cold air blast and by the up run steam, decreased the temperature of the down run gases to an average of 1025 deg; the cold blast boxes reduced the temperature to 625 deg. (a loss of 400 deg;) and the radiation from the lower part of the hydrogen pipe reduced the temperature to 475 deg. (a further loss of 150 deg.)

The relative temperatures found throughout the type No. 2 gas machine are illustrated by the Composite Chart (Plate No. 13.) The chart is composed of records taken from eight parts of the machine during the time between 11:30 A. M. and 2:30 P. M., and arranged in the order of the gas travel. The numbers indicate the position of the fire-end in the gas machine from which the records were taken, as shown in the diagram of type No. 2.

The third diagram shown (Plate No. 10) is upon a type of water gas machine which is seldom seen in use at the present day, but it illustrates very markedly the use to which the pyrometer could have been put as a decided aid in operations in the past. This machine has two generators side by side connected by pipes and valves, above each of which is a fixing chamber filled with checker brick at which point oil is admitted for carburetting the gas. Above this short chamber is another, but taller, fixing chamber likewise filled with checkered brick, much for the same purpose as the superheater in the other types. Each shell has its own take-off pipe, purge cap, wash box, etc. When up runs are made the steam enters the bottom of each generator and the two shells are operated as independent machines. When down runs are made the two shells are operated together as a single machine; steam enters the top of the superheater of one shell, becomes superheated steam in passing through the checker brick, is gasified in passing down through one generator and up through the other; a large quantity of oil is admitted in the second fixing chamber and the gases become properly fixed in the upper portion of the twin shell. It will be seen that after a down run the top courses of one shell will always be considerably colder than the other. To operate two successive down runs, one on one shell and the second on the twin shell, does not overcome this difficulty, as there is always one shell which will have the last down run and that shell will be much colder than the other. Here the pyrometer is a great aid if four fire-ends are installed as shown (see Plate No. 10.) The primary and secondary blast on each machine can then be so manipulated with the aid of the four indicators that the colder shell may be brought to the desired temperature without heating the other shell to an excessive temperature during the blasting period. In this type of machine the top of the superheater may be quickly cooled to the desired temperature by reason of the direct effect of the down run steam.

It may be of interest to you at this time to note a few features of more or less importance in the practical operation of a gas ma-

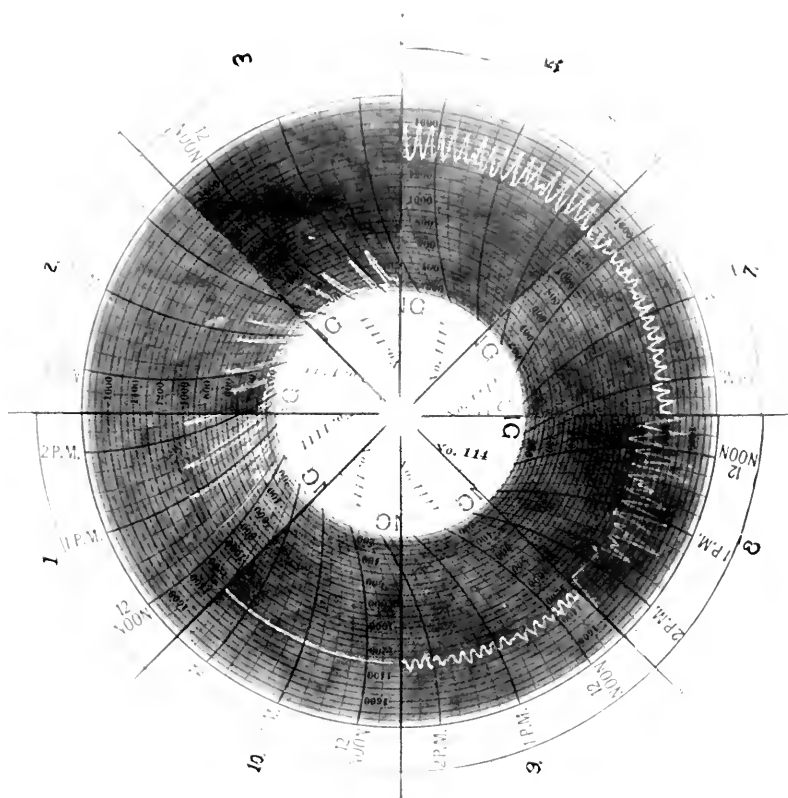


PLATE XIII—Composite Pyrometer Records of Comparative Temperatures on Type No. 2 Water Gas Machine.

This chart indicates the temperature in 8 different points on the gas machine from 11:30 A. M. to 2:30 P. M. The numbers designating each segment indicate the relative position of the fire-ends in the machine and correspond to the numbers on Plate No. 9.



chine which I have observed incident to the use of the pyrometer.

The decided advantage a gas maker has in starting a new machine with the constant and accessible aid of the pyrometer by heating the bricks uniformly and gradually throughout the machine without attaining an excessive temperature in the carburetter, is clearly shown by the fourth chart reproduced with this article. (See Plate No. 14.) The record of temperatures at the bottom of the carburetter indicates that the blast was turned through the cold checkerwork at 1 P. M. August 25, 1910, and that the brick were slowly and steadily heated to a temperature of 1350 deg. at this point covering a period of two hours. At 3:40 P. M. the machine was shut down for 10 minutes to readjust the oil meter. From 10:10 A. M. on the following day to 12:00 M. the machine was cleaned and clinkered. Note the absence of any excessive temperatures during the cleaning time but rather the slight decrease due to radiation.

When gas is made with coke (blasting 4 minutes and running 6 minutes) it is very difficult to detect from the chart, recording the temperatures in the 17th course from the oil spray, just how long the primary blast was used before the secondary was opened; but, when hard coal is used (blasting 6 minutes and running 6 minutes) the chart shows very distinctly the point at which the secondary was opened.

A steam run is readily detected on the chart thus enabling the superintendent to note the carelessness of a gas maker, who may allow the meter to pass an excess of oil for carburetting during a couple of runs and then make the next a steam run to bring the meter statement on the time sheet to the reading of the meter itself. When the gas makers realize that it is possible to check their work they do become more careful. There is a certain moral influence surrounding the pyrometer, a halo of mystery enveloping that chart over in the office, which the average gas maker greatly respects. He will even refrain from smoking in its presence for some months.

Another feature which is readily detected by the carburetter instrument is the action of the oil spray. If it is not properly adjusted, some of the openings become closed with carbon, or the spiral fails to rotate (as in the Johnson spray), the oil will cool the brick in one portion more than another, causing the familiar

"dark streaks" in the carburetter. In this connection I might say that the choice between the use of different types of sprays has been simplified in a large measure. On the one hand a stationary spray was recommended which had no movable parts and required a minimum of repairs but gave a slight "dark streak" in the center of the carburetter which condition could not be avoided, while on the other hand a spray was recommended which had to be raised above the carburetter arch after every run to keep it from the heat of the blast gases and which had movable parts, necessitating occasional repairs, but gave no dark streaks when adjusted. The many advantages of the former spray were not of sufficient weight for its adoption when the pyrometer indicated that this "dark streak" represented a temperature about 1000 deg. F., whereas the temperature of the brick 2 feet from the center was 1350 deg. F.

*omit* ~~could not be avoided, while on the other hand a spray was recommended which had to be raised above the carburetter arch after every run to keep it from the heat of the blast gases and which had movable parts necessitating occasional repairs, but gave no dark streaks when adjusted. The many advantages of the former spray were not of sufficient weight for its adoption when the pyrometer indicated that this "dark streak" represented a temperature about 1000 deg. F., whereas the temperature of the brick 2 feet from the center was 1350 deg. F.~~

The instruments in the carburetter and superheater aid the gas maker in determining the condition of his generator. If the stack gases show excessive flame at the purge cap (due to the combustion of an excessive supply of carbon monoxide formed in the generator) when the temperatures in the carburetter and superheater are at the desired points, the fire is too hot and the primary blast valve should not be opened so wide during the following blow. When the fire is not hot enough to generate sufficient carbon monoxide to heat the checker work to the desired temperature and to show a thread of blue flame at the stack toward the end of the blow, more primary blast should be given to the generator. By operating in such a manner the pyrometer will aid materially in maintaining a good fire, and reduce the amount of coke wasted by excessive blasting with the primary.

I recall one very interesting incident which occurred about a year ago. The recording chart taken from the instrument on the morning of a sweltering July day indicated a decided drop in temperature every run or two during the previous afternoon and night. After the oil spray had been examined and found to be in excellent condition, the chart was again referred to and studied more closely.



It was noted that there was a certain regularity to the repetition of this increased variation in temperature (about twice the average variation); that it occurred every second and third run in the same order in which the down runs occurred. Upon examination of the hot valve between the top of the generator and the hydrogen pipe, a small quantity of coke breeze was found in the seat of the valve which prevented a tight seating of the gate during a down run and permitted live steam to escape from the top of the generator to the carburetter, causing the increase in the cooling of the brick during the run. It is needless to say that the trouble was immediately remedied.

Before giving a short summary of the results obtained with the pyrometer in carburetted water gas machines it will be hardly necessary for me to emphasize a few points which I consider of chief importance. Lamp black, I believe, is formed to a large extent when the machine is started up after rechecking with new brick. The heat in the top of the carburetter is allowed to run too high so as to obtain the desired cherry red heat in the superheater as soon as possible. Lamp black is also formed by excessive temperature on the checkerwork after the machine has been idle during the clinking time caused by the natural draft through the carburetter and superheater. Methods employed to overcome these difficulties have been previously discussed.

The theoretic operation of a water gas set would be the manufacture of gas with as high a temperature as possible in the checker brick without the formation of lamp black and thereby obtain the greatest possible proportion of fixed, gaseous hydrocarbons. In practice we find other factors entering the problem which limit the temperatures to be carried in the superheater, and it will be noted how narrow these limits are. Temperatures above 1500 deg. F. produce considerable lamp black in the superheater. A machine which carries 1450 deg. F. in the superheater would produce some lamp black and would fill the works with naphthalene in a short period of time. One carrying 1400 deg. F. produces some naphthalene trouble but practically no lamp black. Machines operating from 1300 deg. to 1350 deg. F. produce hardly a trace of naphthalene in the entire plant. Under 1250 deg. F. the machines have dirty seal pots showing tar and uncracked oils. The practical limitations in gas machine control are then complete decomposition of the heavier hydro carbon oils and no serious trouble from the formation

of naphthalene, i. e., clean seal pots and a minimum amount of naphthalene. Best practice keeps the temperature of the superheater between the rather narrow limits of 1300 deg. to 1400 deg. F. These temperatures are based upon the use of gas oil having a gravity between 33 deg. Bé and 35 deg. Bé of approximately the following analysis:

FRACTION	% BY WGT.	SP. GR.	°B.
From 0° to 300°F	1.79	.7666	54°
300 to 400	6.30	.8016	46°
400 to 500	25.49	.8299	40°
500 to 600	36.12	.8541	35°
600 to 700	24.44	.8820	30°
700 and above	5.86 Residue Tar.		

Sp. Gr. of Oil= .8630 corresponding to 33.2° °Baume

Flash point= 164° °F.

Burning point= 196° °F.

In a general way it may be stated that with a given quantity of oil used to carburet the water gas a temperature of approximately 1250 deg. in the fixing chamber will yield a gas of about 16% methane with correspondingly low heat value, while temperatures approximating 1350 deg. would yield a gas with nearly 20% of methane, and relatively high B. T. U. and temperatures approximating 1400 deg. would yield a gas containing as high as 22% methane.

In conclusion I wish to summarize in a brief way the principal results obtained by the pyrometer, directly or indirectly, in the practical operation of a carburetted water gas set.

The first and probably most essential point is that a uniform temperature can be maintained in the machine and unless the gas

maker has had considerable experience this is a condition difficult to obtain without an instrument.

Second, the carburetting and fixing chambers have been closed during the clinkering time in such a manner as to prevent uneven and excessive temperatures.

Third, methods of operating the blast valves have been devised so as to maintain a healthy condition of the generator fire, with a minimum waste of carbon monoxide gas burning at the stack.

Fourth, the absence of lamp black on the checker work when the machine is shut down for repairs is an indication that the oil for carburetting has been utilized to the best advantage.

Fifth, the freedom of the works from naphthalene has solved many problems, especially the disadvantages of using oxide saturated with the light, flaky crystals in purification of the gas.

Sixth, the gas maker can operate his machine more carefully and intelligently with the constant and accessible indication of the temperatures in various parts of the machine.

Seventh, the continuous record of temperatures carried on each machine by night as well as day shifts in the office where the superintendent may find ready reference, is of untold value.

Eighth, the indicator and recorder will easily show the condition of the oil spray. The charts indicate very clearly the time taken by each machine in charging, clinkering, repairing or waiting.

Ninth, the pyrometer may be utilized to indicate the useful life of the checker brick.

Tenth, a better knowledge of the exact temperatures found in various parts of the machine becomes very useful in practical operations.

Eleventh and final, the extended use of the pyrometer in operating all the machines in the plant under a given temperature for a considerable period of time, and subsequently under other known temperatures for sufficient time, has proven of great value in determining the practicable range of temperature for good operating conditions in the carburetted water gas machines.

# CHAMBER OVEN PROCESS OF COAL GAS MANUFACTURE

*By JOS. C. MARKLEY, Chicago*

The type of Chamber Ovens to be described is that built by the firm of August Klönne, Dortmund, one of the older builders of coal gas apparatus in Germany.

For the purpose of making observations and becoming familiar with this process, the writer visited a number of plants employing the Chamber Oven process and was given access to the records in a number of instances so that a portion of the data collected, represents working conditions.

The firm of Klönne has developed the process from an experiment made in 1892, when they built a setting of inclined ovens designed for carbonizing 5 tons of coal each Chamber in 24 hours. This installation did not produce the results expected and was abandoned, the study of the principles involved being carried on, however, in connection with the firm's coke oven work.

The first horizontal chamber oven was erected in Rotterdam in 1908 at the Oostzeedyke Gas Works. The gas from the oven is handled independently through separate apparatus so that the results are accurately known. This Company is now building an extension to its works, the generating apparatus to consist of 10 horizontal ovens of four chambers each.

The following works employing the chamber oven process were also visited:

Rixdorf Works, Berlin, 5 Horizontal ovens of 4 chambers each  
Koenigsburg, Germany, 6 Inclined ovens of 4 chambers each  
Frankenthal, Germany (2 Horizontal ovens of 3 chambers each

(1 Horizontal oven of 4 chambers each

Dortmund, Germany, 1 Vertical oven of 4 chambers

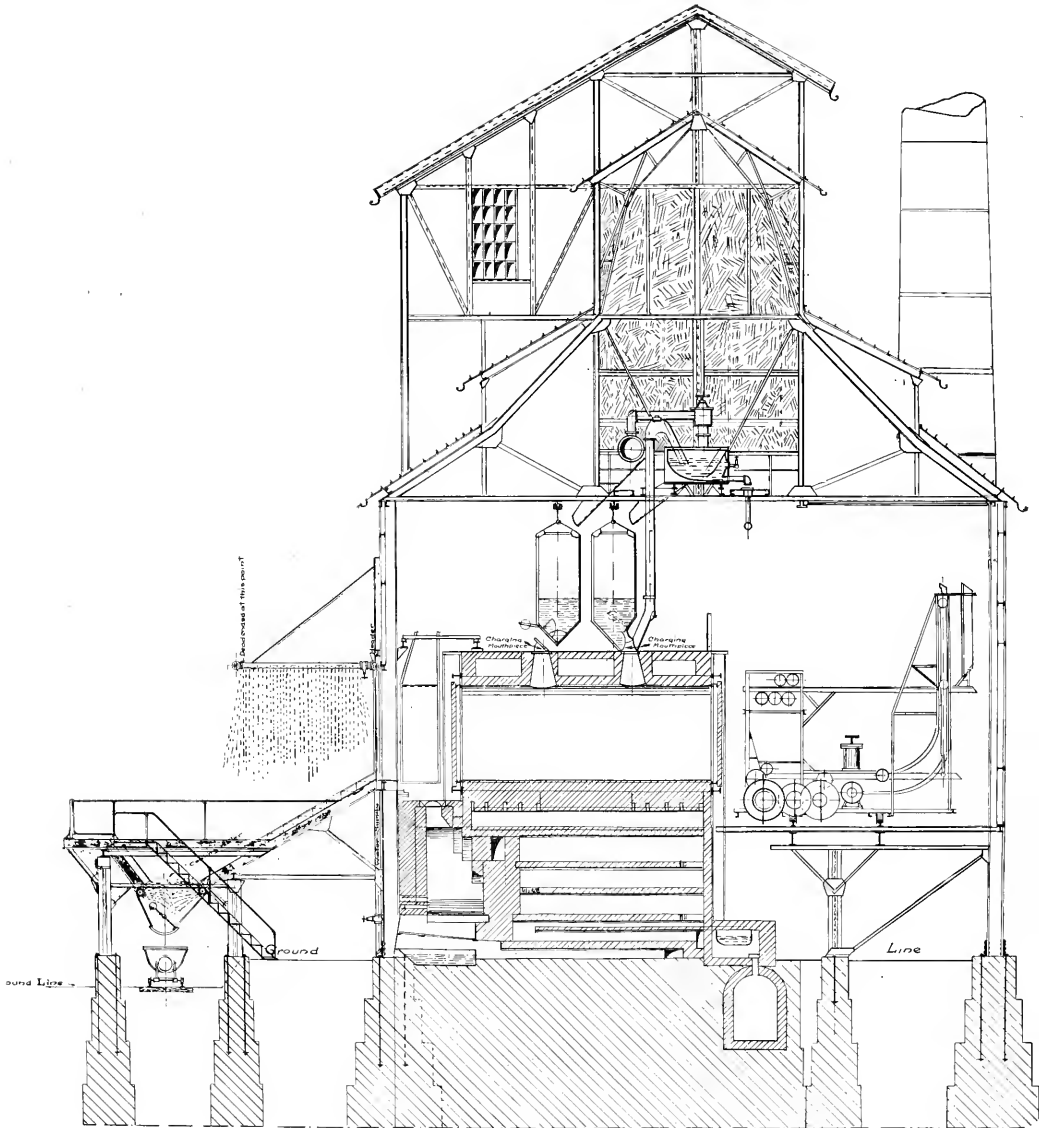
Padua, Italy (2 Horizontal ovens of 4 chambers

(4 Horizontal ovens of 2 chambers each

Brussels, Belgium (2 Horizontal ovens of 4 chambers each

(2 Horizontal ovens of 3 chambers each

Horizontal ovens are also employed at Versailles, France, where there are two of the Klönne ovens of 4 chambers each.





The special features of the process as finally developed include:

1. Carbonization of the coal in bulk and saving in ground space.
2. Saving in labor and elimination of night work excepting for firing of generators, which is done every six hours by one man.
3. Moderate heats with attendant saving in maintenance cost.
4. Elimination of standpipe troubles and pitch in the hydraulic.
- Good yield and heating value of gas, with freedom of carbon deposits in the chambers.
6. Liquid tar, low in carbon.
7. Mechanical means of regulating texture of coke.

These points will be brought out in detail, but first a description of the chamber ovens and the methods of operation are in order.

The horizontal ovens are built on several plans to conform with local conditions, capacity required, etc., that is, the ovens are built to contain either two, three or four chambers each and the chambers vary in length from 14 ft. 9 in. to 19 ft. 8 in. The inside height is about 6 ft. 6 in., and the width 16 in. The charge per chamber is from 4 to 5 gross tons of coal, which may be carbonized from 18 hours to 36 hours depending upon the demand for gas. The capacity is based on a carbonizing period of 24 hours, which makes the system sufficiently elastic to meet the changing conditions of send out.

The accompanying cut illustrates in a general way a horizontal section of a chamber oven plant. I found that several different designs of buildings were employed at the different works and also various modifications of coal handling apparatus. The buildings were usually of a structural steel skeleton with brick filling on three sides. In one case the building consisted simply of a steel frame work supporting the coal bunker and an arrangement of shelter roof for the protection of the workmen.

In operation, the coal is crushed (when necessary) and conveyed to the bunker built over the ovens, preferably at one end of the stack.

The chambers have two or three (depending on their length) self sealing charging mouth pieces on top, through which the coal is charged from overhead hand traveling hoppers, the coal being spouted into these hoppers from the bunker. One man on top of the ovens attends to the opening of the mouth pieces and charging of the coal.

On the operating floor in front of the ovens is an electrically driven traveling machine which is operated by one man. This machine performs three functions; opens the front door of the chamber, levels the coal in the chamber, after it is charged, and pushes the coke from the chamber after the carbonizing process is finished.

A third man is stationed at the back of the ovens and it is his duty to handle the back doors of the chambers during the periods of charging and discharging. These doors are quite heavy, being made of a solid steel forging and are handled with a small traveling machine designed for the purpose. It is also the duty of this third man to charge the generators during the day time, which is done every six hours, with cold coke. A traveling hopper is filled on the ground and then hoisted to the proper level when it travels along the back of the ovens, the coke being spouted to the generators.

The complete process of discharging the coke from the chambers and recharging with coal required, at different works, from 12 to 15 minutes for each chamber.

After carbonization, the coke lies in the chamber in the form of a huge block, with an open space of about an inch next the side walls of the chamber. When pushed from the chamber by the machine, the mass of coke splits vertically in the center forming two sheets or slabs about 7 in. thick and when it falls onto the quenching floor it breaks up into long pieces as shown in the accompanying photograph:

The material used in the construction of the chamber ovens is highly silicious and the temperatures observed at the Rixdorf plant with a Lunette pyrometer were 2000 deg. F. to 2140 deg. F. in the combustion chambers. The heating does not continue to the top of the chambers, the gas space over the coal being the coolest part. These temperatures were the highest observed, lower temperatures being carried at other works.

At several of the works there were chambers that had been let down by reason of curtailed demand for gas. An examination of these cold chambers showed a very slight warp of the chamber tile, due to contraction, but no cracks. The contraction caused the joints to give somewhat and, after an oven was let down, the practice was to pick out the clay and point up the joints with a retort cement. In laying the chamber tile, the joints are all broken giving very little chance for leakage. In none of the chambers in operation could be detected any furnace gas leaks. In the experi-











mental oven at Rotterdam which was not in operation at the time of my visit, the chamber tiles were much larger and of a different mix than later adopted. The walls showed some cracks and the tile showed a decided warp.

The common practice of clinkering is every second day, that is once every 48 hours. One man does this work and it requires about an hour for each fire.

At the Rixdorf works the question of scurfing the chambers came up for discussion and a demonstration was made that was somewhat out of the ordinary. Practically all of the carbon forms on the floor of the chamber although instances were noted where a slight deposit had formed on the side walls. A chamber was selected that had been in continuous operation for eight months and the carbon on the bottom varied in thickness from about  $1\frac{1}{2}$  to  $2\frac{1}{2}$  inches. An ordinary garden hose was brought into play and the floor of the chamber was flooded with water until it became black. Scurfing bars and sledges were used, the work being done at both ends of the chamber simultaneously, until the bottom blocks came up to heat again when more water was applied. The entire operation was completed in three quarters of an hour. In discussing this process later with the builders of the ovens, the chief engineer did not discourage the practice, but at the same time said that he did not recommend such heroic treatment. Later advice from the Engineer of this works is to the effect that although the practice of pouring water on the floor of the chamber is still continued, the quantity of water used is not so great as formerly. A long pipe, with small staggered holes drilled in the underside, is now introduced into the chamber and the water is applied to the floor in the form of a fine spray.

In rare instances a carbon deposit on the side walls may interfere with the discharge of the coke from the chamber, although but one such case was noted during the six weeks spent on the work. In this case the pusher could not start the coke after several trials. The chamber was then left open until the next chamber was discharged and during the fifteen minutes sufficient air was admitted to burn the outer surface of the coke next the chamber walls. The coke was then easily discharged. The carbon deposit was then removed from the side wall in a few minutes.

The various advantages of this system of coal gas manufacture were brought out at the different works and the several engineers were, without exception, very enthusiastic over their results. Among the points observed particularly were the following:

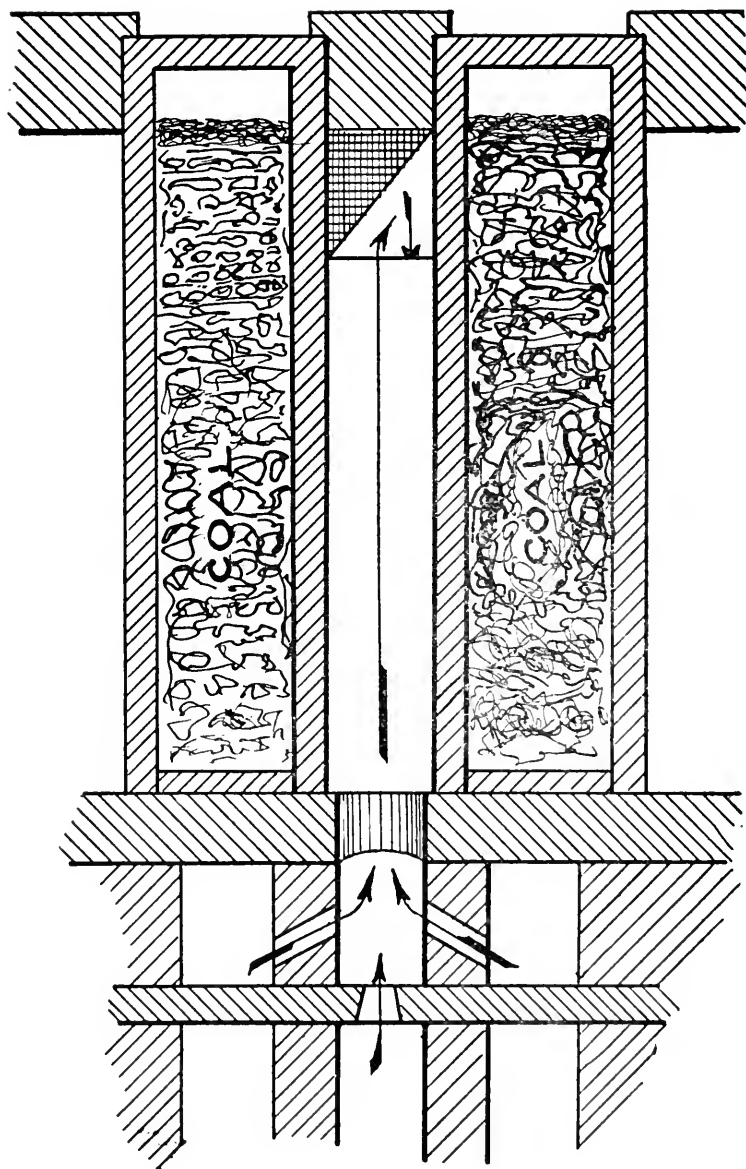


FIGURE : 2

**First:..Carbonization of the Coal in Bulk.** This practice seems to be the tendency of late years. Even with horizontal retorts there are recent instances of better results being obtained by the use of heavier charges of coal and longer periods of carbonization; the object being to prevent the bulk of the gas from remaining in contact with the highly heated surface of the retort.

In the Klönne type of chamber oven, the top part of the chamber is the coolest. The furnace gases flow upward in the vertical flues, at either end of the chamber, to the top level of the charge and then take a downward course at the center as per Figure 2.

**Second:..Low Cost of Carbonizing Labor.** The question of handling the coal to the overhead bin and the removal of the coke to the yard, naturally depend upon the type of coal and coke handling machinery adopted. The coke handling is more of a problem with the use of chamber ovens than with retorts due to the large quantity of coke discharged at one time, but it can be easily handled by building the quenching floor on an incline in the form of one big pocket with smaller chutes extending below the bottom level of the quenching floor. These chutes may then be emptied at leisure. At all of the works visited the coke was quenched with a large fire hose, although various forms of quenching machines have been designed by the manufacturers of the ovens.

The actual labor for carbonizing the coal is performed during one shift of 8 or 10 hours, depending upon the size of the plant and the time of day selected for the richest make of gas. At night one man only remains with the ovens and it is his duty to charge the furnaces once every six hours. Three men on the day shift can readily handle 24 chambers with a carbonizing capacity of 120 tons of coal per 24 hours. An extra man every second day would be required for clinkering the fires. This same complement of men is required for a plant of less capacity, but for a plant carbonizing 60 tons per 24 hours, the same men would be able to handle the coal to the overhead bin and the coke to the yard, provided, of course, the necessary coal and coke handling apparatus were provided.

In Frankenthal, Bavaria, where the Klönne ovens are installed Sunday labor at the gas works is practically dispensed with; however, this is due to the large amount of gas sold to the refiners of precious metals who shut down on Sunday, and the domestic gas demand can be supplied from storage.

**Third: Moderate Heats with Attendant Saving in Maintenance Cost.** The temperatures observed, ranged from 1900 deg. to 2140 deg. Fahrenheit, only one of the several works carrying the higher temperature. The massive construction of the chamber ovens, considered with the fact that very little scurfing of carbon is required and that only on the floors of the chambers, which are built up of blocks about 16 in. thick, would give promise of long life. Coke ovens, built along similar lines, have been in continuous operation for six years before renewal of carbonizing chambers were required. The coke pushing machine is of simple design and heavy construction indicating low cost of repairs. The remaining portion of the mechanical auxiliaries such as charging hoppers and machine for handling discharge doors, have very few moving parts to cause wear.

**Fourth: Elimination of Stand Pipe Troubles and Pitch in the Hydraulic Main.** No troubles of this nature were observed and I was informed by several engineers that they did not occur. However, an auger is used in the standpipe, the same as in retort practice, a hand hole being provided at the lower end of the ascension pipe for this purpose. Tar drawn off from the bottom of the hydraulic is quite thin, the absence of pitch being due to the moderate heats.

**Good Yield and Heating Value of the Gas.** The average yield per lb. of coal from the chamber ovens is not particularly remarkable excepting when the quality of coal used in Germany is considered. English coals are used to a great extent and often mixed with German coals, English coal being a trifle less in cost. These coals contain from 27.5 to 33% volatile. One is impressed with the uniformity of the average yield at various works. At the Padua plant the average yield, corrected, for a period of seven months during 1910, was 5.14 cu. ft. per lb. of coal, as compared with a yield of 4.46 cu. ft. per lb. of coal during the same period the previous year with horizontal retorts and the same grade of coal.



The coal used was a mixture of "New Bolton" and "Holmside," English coals of 32.2 to 33% volatile. At the Rixdorf works using a mixture of English coals, "Lambton" and "Hebburn," and "Dubensko" from Silesia, the yield for the month of July 1910 was 4.956 cu. ft. per lb. corrected. The volatile matter contained in these coals is something less than the "New Bolton" and "Holmside," viz: "Lambton" 27.5 to 29.95%, "Hebburn" 29.9 to 31.8%, "Dubensko" 33.35%. The proportions of the mixture were 75% English and 25% German coal.

Verv little attention is paid to candle power at any of the works, but the calorific value is watched very closely even in the smaller plants. At a number of places were employed the Junker automatic calorimeter which contains a chart on which is automatically drawn a curve, indicating the heat units of the gas every instant during the 24 hours. "The principal of this automatic instrument is based on the formula

$$\text{Heating value "H"} = \frac{\text{Amount of Water "W"} \times \text{increase of temp. "T"}}{\text{Amount of gas "G"}}$$

The value of W-G is kept constant, and by this means the increase in temperature of the water, as the only variable figure, represents the scale for the heating value of the gas. The exact proportion of water to gas is obtained by coupling a gas meter to a water meter of special design, thus the amount of gas per revolution of the meter represents a certain amount of water flowing through the calorimeter. A thermo-electric pile is connected to the calorimeter through which the stream of cold and warm water flows. The construction of the thermo-electric pile is based on the principal that in two metals, soldered together at one end, an electric current is generated if the soldered joint is warmed to a higher degree than the free ends. The tension of current thus generated is in exact proportion to the difference in temperature, consequently the heating value of the gas is also in proportion to the tension of the electric current generated. The tension of the current is measured by means of a very sensitive milli-voltmeter. The milli-voltmeter is provided with a caloric scale, divisions of which are fixed after having found the proportions of temperature increase to the tension of the current. The pointer of the milli-voltmeter is provided with a pen which draws a curve on the chart reading directly in calories." Where this instrument is used it is checked up once each week with the ordinary calorimeter.

**Sixth: Liquid Tar, Low in Carbon.** A sample of tar obtained at the Rixdorf works and submitted to an American chemist, showed the following analysis:

Specific Gravity	1.1359 @ 68 deg. F (20 deg. C)
Water	2%
Free Carbon	3.31%
Tar acids	6.1%
Napthalene	7.6%

#### DISTILLATION

Distillates	Amount	Spec. Grav. @ 68 deg. F.
to 110 deg. C (Water)	2%	.....
110 deg. to 235 deg. C	12%	1.0016
235 deg. to 250 deg. C	8%	1.023
250 deg. to 270 deg. C	3.5%	1.039
270 deg. to 300 deg. C	6%	1.051
300 deg. to 315 deg. C	2%	1.069
315 deg. to 360 deg. C	12%	1.092
Residue (by weight)	54%	1.288

The residue above 360 deg. was a moderately hard pitch; softening at 55 deg. C (131 deg.F.) and melting at 70 deg. C (158 deg.F.)

The Napthalene is reported as solid napthalene pressed from its oils. The total amount of napthalene bearing oils is the sum of the distillates from 110 deg. to 270 deg. C or 23.5%.

The distillates from 300 deg. to 360 deg. were solid anthracene oil.

A sulphuration test was made with positive result. This indicated the presence of a small amount of paraffins or paraffinoids. This often occurs with certain coals, and does not necessarily mean that oil tar is present.

The Free Carbon is very low for a coal tar. The amount of tar acids is moderate. The Spec. Gravities of the various fractions are somewhat lower than for similar fractions of coal gas tar and would seem to indicate the tar to be a coke oven tar. The amount of solid naphthalene is only fair. Some tars contain 15 to 20%.

The residue above 360 deg. is an excellent pitch and being 54% of the whole, means that 45-46% of this tar can be distilled and a good quality of pitch remain.

**Seventh: Mechanical Means of Regulating Texture of Coke.** An ingenious device is employed in the construction of the front and back lids of the chambers, which permits somewhat of control-

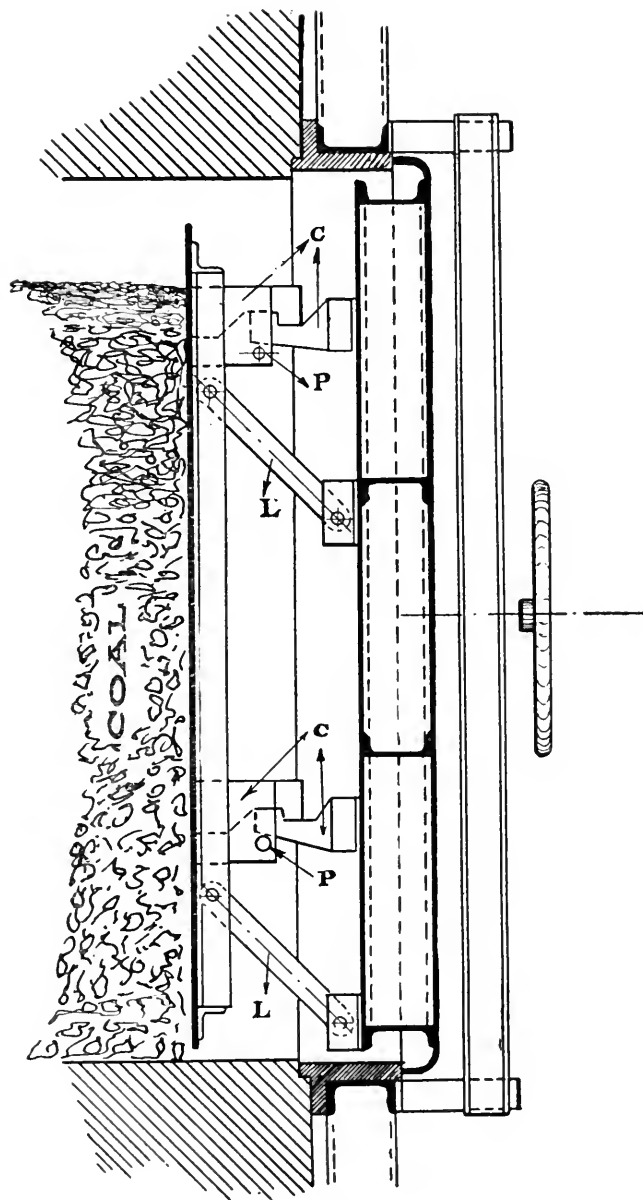


FIGURE 3.

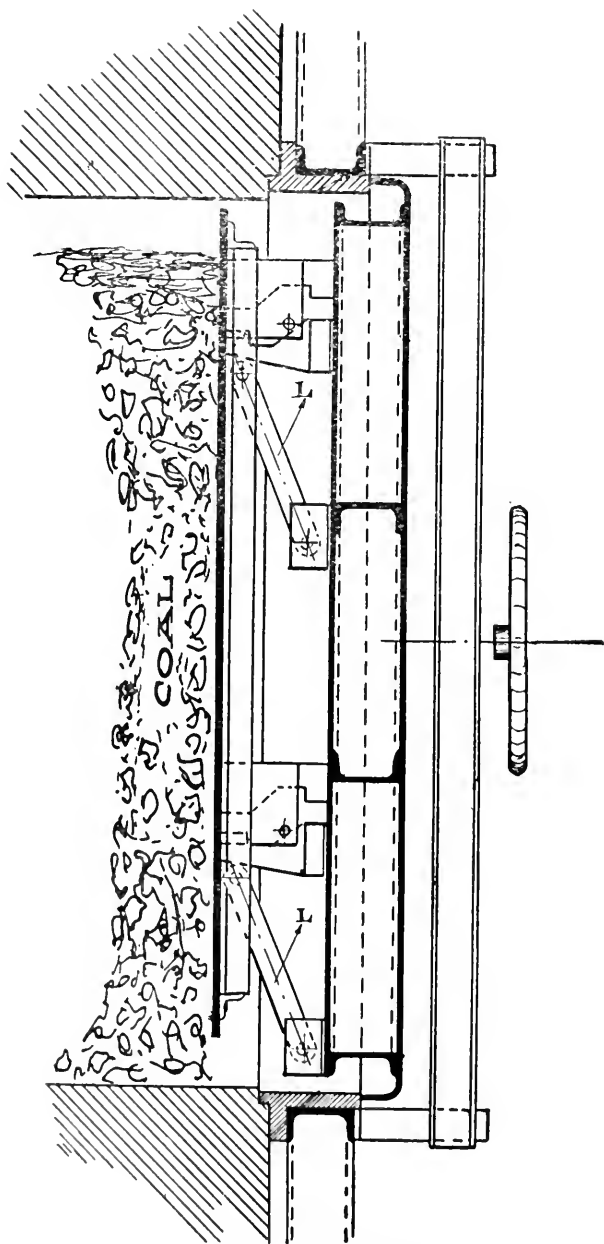
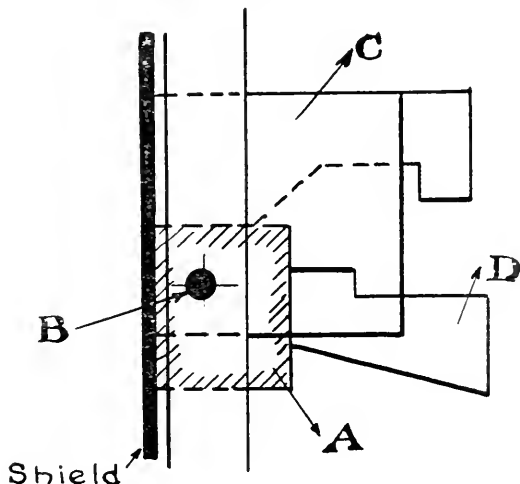


FIGURE 4.

ling the hardness of the coke to meet the demands of the market. The arrangement consists of an inside shield which is hinged to the lid or door by heavy links which are marked "L" in Figures 3 and 4. When a very hard coke is desired, pins "P" are inserted under the latches which compel the shields to remain stationary, thus exerting pressure on the coal when it begins to expand with the first heating. This condition is shown in Figure 3. Should a soft coke be desired, the pins are not inserted and this permits the shields to ease back with the full expansion of the coal. Figure 4.



## FIGURE 5

There is also a provision for allowing the shields to give but part way with the expansion of the coal, thus exerting somewhat less pressure than in the first instance and produces a coke of medium hardness. This is shown in Figure 5 and consists of a cast iron block "A" which may be inserted under the top latch "C" and held in place by pin "B." When the coal has expanded a certain amount and the shield is pushed toward the lid or door, the block "A" comes in contact with latch "D" and therefore cannot move any farther. Pressure is then exerted on the coal as it continues to expand.

As an illustration of the texture of chamber oven coke as compared with retort coke from the same coal, the Engineer at the Rixdorf works, Mr. R. Heine, gave me the following figures:

Weight of Chamber oven coke = 37 lbs. per cu. ft.

Weight of Retort coke = 31 lbs. per cu. ft.

Here the coal is allowed the full expansion as the coke is all used for domestic purposes.

Some interesting observations were made at the Padua plant, August 12-13, in company with Dr. Ott of the Zurich works and Engineer Westhofen of Dortmund, with the following results:

6:00 A. M. August 12th to 6:00 A. M. August 13th.

"Holmside" (English) coal charged 70,560 lbs.

Gas produced corrected 351,840 cu. ft.

Gas produced per lb. of coal 4.98 cu. ft.

Average heating value, gross 633 B. T. U.

Analysis of "Holmside" coal:

Coke and Ash	67.8%
Volatile,	32.2%
C.	82.04%
H.	5.
O.	5.38
N.	1.36
S.	1.52
Ash	3.36
Water	1.34

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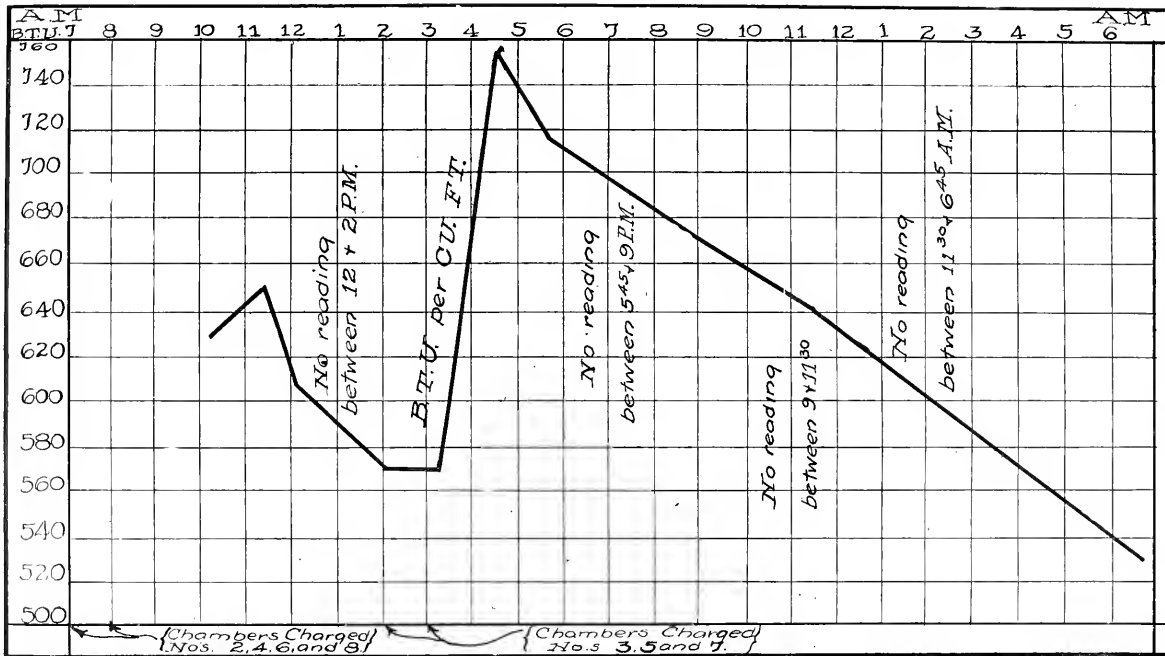
100.00%

Curves were plotted, showing hourly production and calorific value and are fairly characteristic of the chamber oven process.

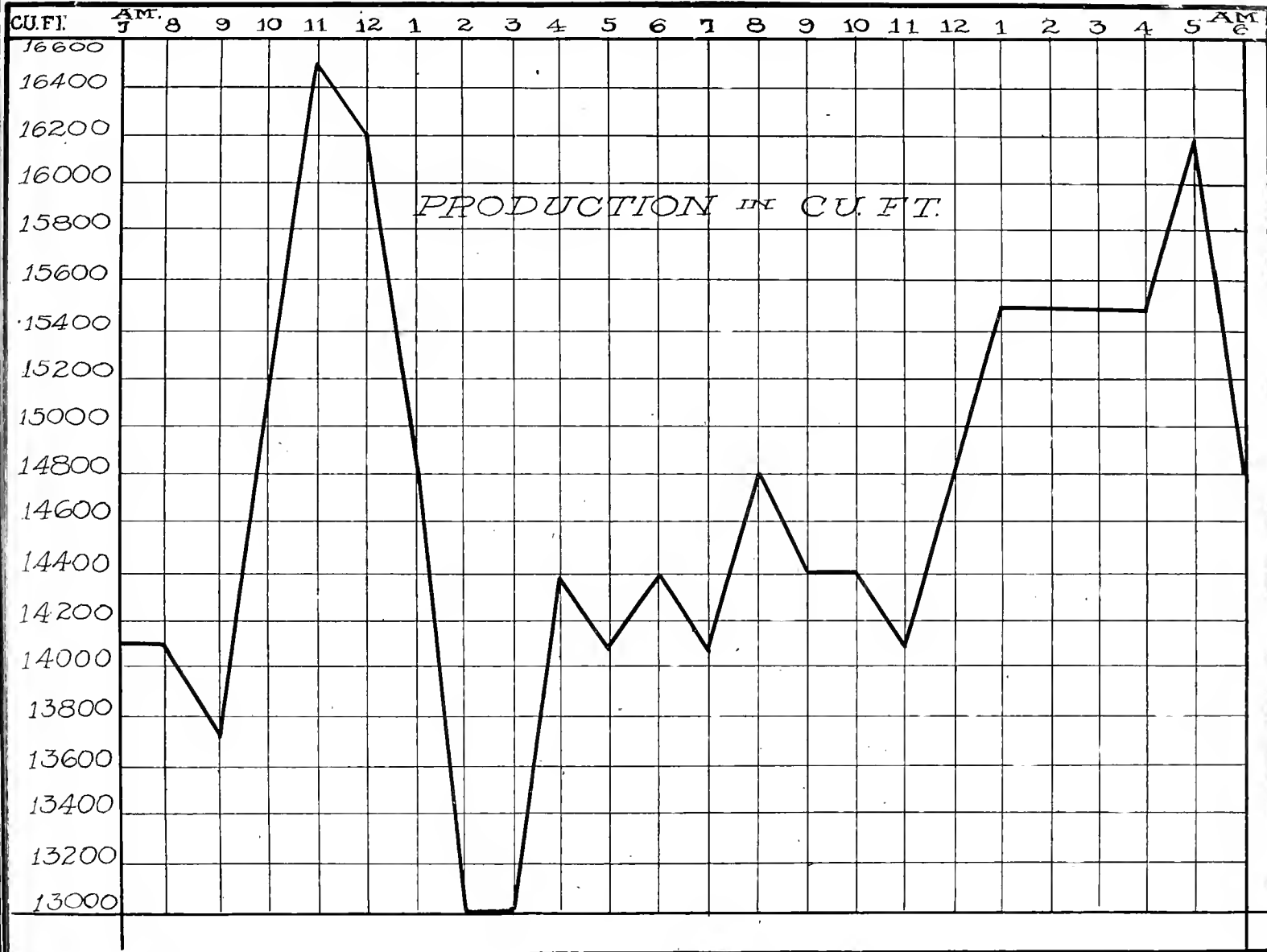
It is noted that alternate chambers were charged at each period, viz: chambers Nos. 2, 4, 6 and 8 between the hours of 7:00 and 8:00 A. M. Chambers 1, 3, 5 and 7 between the hours of 2:00 and 3:00 P. M. Eight chambers in all were in use. The production readings were taken from the station meter, while the gas for calorific test was taken before entering the holder.

The following curves were furnished by M. Sissingh, Director of the Oostzeedyk Works, Rotterdam, however no figures were obtained at this plant:

In conclusion, the thought is suggested that there are possibilities for the chamber oven process in America in utilizing local coals, or at least a mixture of local coals with Youghiogheny or Pocahontas when a better grade of coke is desired. With Youghiogheny coal only, better results should be expected than are being obtained abroad, due to the higher percentage of volatile hydrocarbons contained over that of the German and English coals.



HEAT UNIT CURVE  
 PADUA  
 MAX. 158 B.T.U. MIN. 53 B.T.U. AVG. 633

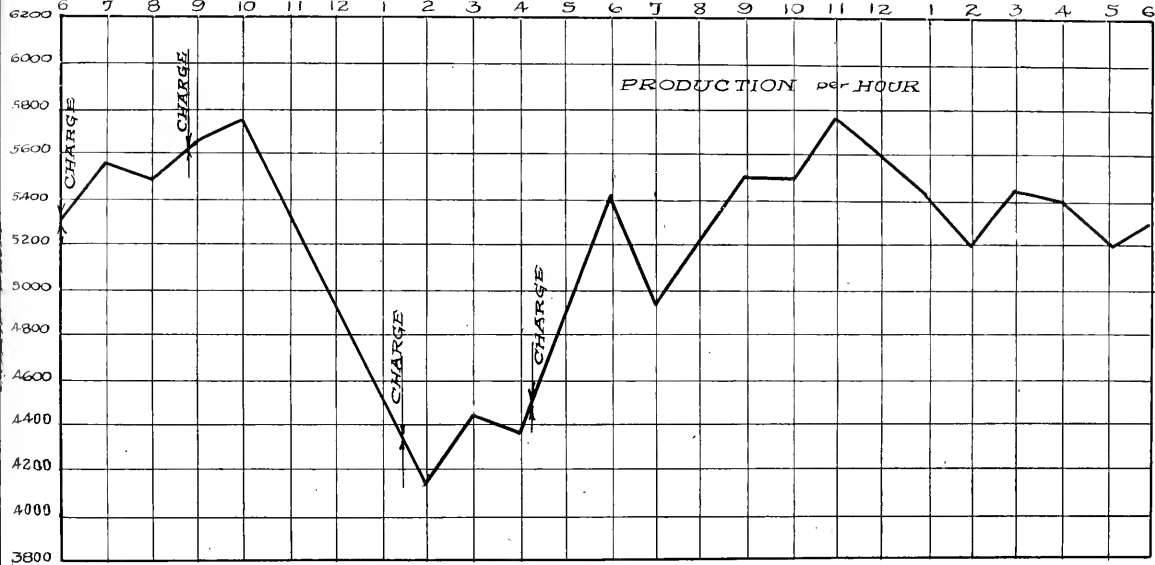


*PRODUCTION CURVE  
PADUA*

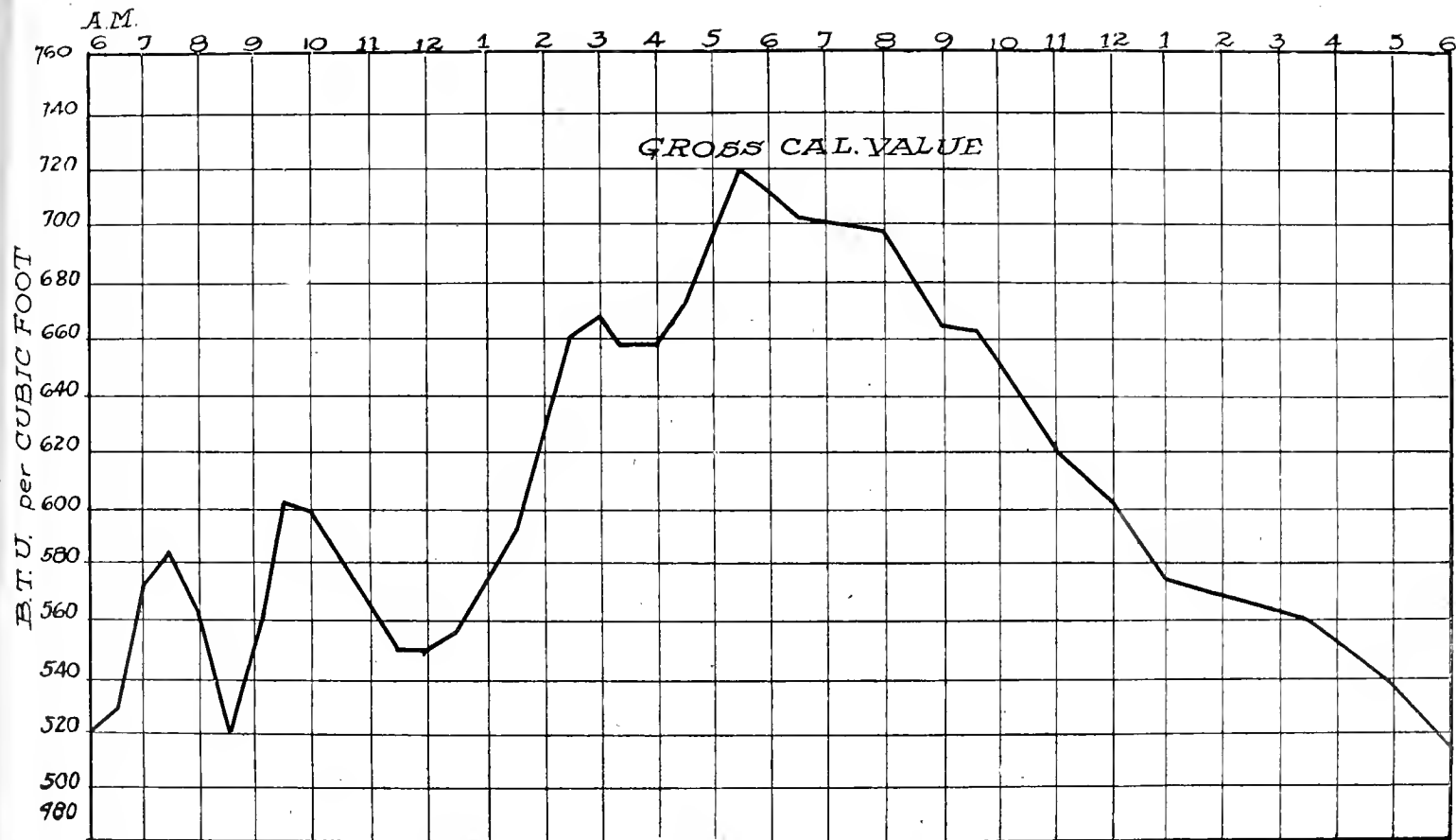
*MAX. per hr. 16500 CU. FT. MIN. 13000 CU. FT. AVG. 14530 CU. FT.*



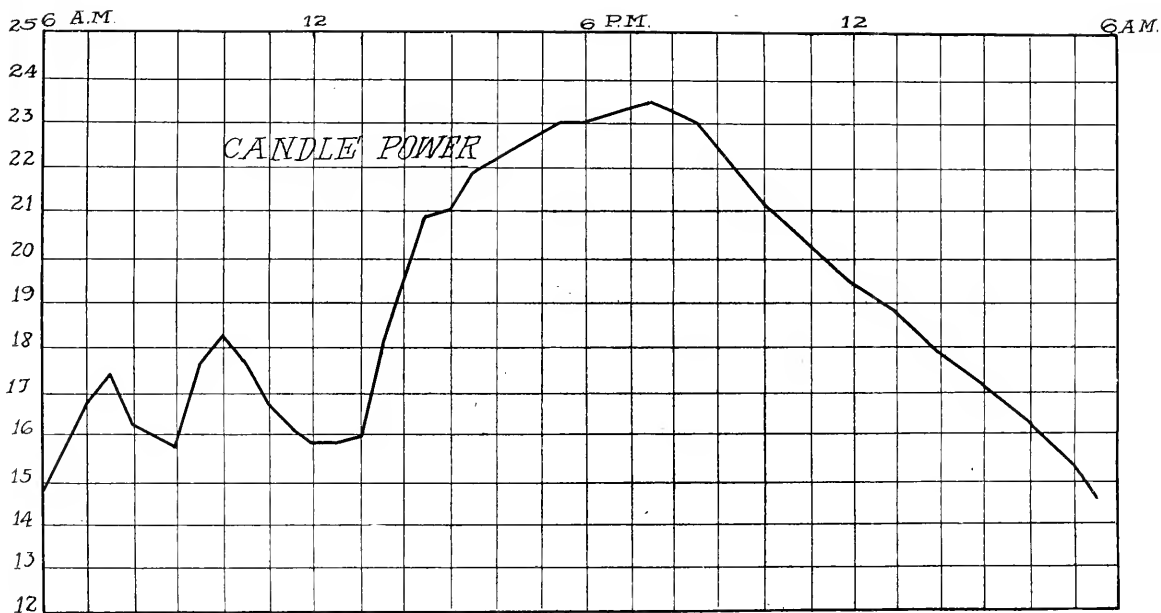
TIME 6 AM



HOURLY PRODUCTION  
ROTTERDAM.



ROTTERDAM  
GROSS HEAT UNIT CURVE



ROTTERDAM  
CANDLE POWER  
MEASURED WITH METROPOLITAN-ARGAND-BURNER No.2



## THE OPERATION OF THE AMMONIA STILL

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*By A. F. BLOSSEY, Alton, Illinois*

Since it is not within the province of this paper to give costs of installation, nor yet of operation—for these vary with the kind and size of still, the locality, and especially the method of operation, you will be content with the barest limit that the subject can be confined to. It will be necessary to introduce a few points, however that will lap the cost line. There is the ideal fuel consumption required per ton coal carbonized, as laid down by the manufacturers of stills, against the real fuel consumption. The cooling water is also a consequential item in some places. Cost of labor must likewise be taken into consideration. It will be necessary to also introduce accessory appliances—the hydraulic main, the condensers and scrubbers, and the storage tanks. Without proper saving of the crude liquor, the very best operation of a still would appear to be a failure.

First, let us assume that the question of installing a still has come before the advisory board of a small Gas Plant. The Superintendent, having the best interests of his employers at heart, has recommended the installation, and to back his claim for the extra earning power of the appliance, has procured and arranged a vast quantity of data on costs of installation and on earnings on investment.

Now grant that the figure, backed by eloquence and supposed knowledge, have won out and that the material for the still has arrived. In the estimate the cost of erecting the apparatus has been purposely decimated, for the Supt. has had experience in concrete and structural work. By the help of cheap labor to do the strong acts under personal direction, a material saving is to be made.

At the end of a month there are still many minor connections to be made, while the labor item has far exceeded the allowance in the proposed expenditure.

On the day for testing out the still, the Supt. appears on the job early, armed to the teeth, with manufactured instructions. During the 18 hour run he discovers: That the retort house men either question their capacity to operate so complicated a machine, or fear that extra work will be required of them—probably the latter. That it is absolutely necessary to keep a constant pressure on the steam line, while the 30 H. P. Boiler, fired at the convenience of the retort-house men, and with breeze and slack for fuel, fluctuates between 50 and 80 lbs. pressure: that there is a big waste of cooling water, which keeps the meter humming up a record at a comfortable price per M., and that at the overflow to the concentrated liquor tank, the liquor, which is already contracted for on the 15% basis, is at best but 6%.

With the help of his all round man, usually called the pipe fitter, the Supt. attacks the problems.

On the lower section of the absorber, and adjacent to the seal pot, he attaches a swinging overflow pipe. When the liquor is weak, the pipe is to be lowered to a connection with the seal pot, and the liquor be returned to the crude liquor tank. Raising the connection will again force the liquor through the regular outlet.

A test having revealed that the crude liquor in the underground tank is at almost a constantly low temperature the year round, while the city water becomes too warm in summer to be effective for cooling purposes, the liquor is utilized in the condensers. A small amount of pipe fitting diverts the cold liquor to the upper cooling sections of the absorber before discharging it into the top section of the volatile still. The change serves a double purpose. The cooling water required in the lower sections of the absorber, is cut to a minimum and the crude liquor is very sensibly preheated before entering the volatile still.

The boiler proves to be the next greatest problem. There seems nothing for it but to provide a better grade of fuel and more regular firing. And the firing question brings him to the real problem—the men.

Every successful gas man knows that what he must have above all is not operation but co-operation. And with this maxim in mind, the Supt. approaches the foremen of the two shifts at the

changing hour, with a "Now men, let's show 'em that we can conquer the brute." A list of instructions on how to start, operate and stop the still is left with them with the understanding that the instructions are guides, not orders. A suggestion to the night man, to "try his wings," finds the still hot and ready for an early start in the morning.

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Though things appear to run smoothly and all minor troubles are conquered, the Supt. finds at the end of the month that he has recovered only 2 or 3 pounds of ammonia out of a possible 4 or 5 lb. per ton coal carbonized. The steam coal which has been entered in the operating expense account at 24 lbs. per ton coal carbonized, proved to be fully doubled. Also the labor account—which should be nil—is a very material item. Later follows pump lubricant and repairs, valve and cock repairs and renewals, extra labor for cleaning and overhauling still, until the earnings balance has become so small that the management calls for an explanation.

The problem now, is to discover the leakage of those extra pounds of ammonia. Beginning at the hydraulic, the cold water is substituted by a hot circulating system. The tar ammonia separator is carefully regulated and watched. The scrubber circulating system and the flush regulation are systematically operated and adjusted. Tests at regular intervals are made at outlet of No. 2 scrubber and the whole still is carefully tested for any possible leaks.

Persistent and systematic following up necessarily bring results, and unless the Supt. or one of his men equally interested in getting results makes it his daily duty to look after the seemingly small matters, the yield will drift back to the 2 lb. mark, or even lower.

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For convenience, the Supt. and the foremen of a gas plant should have a pocket memorandum of useful notes, personally gathered from manufacturer's bulletins, engineering hand books, journals and from personal observations. Among these notes could be placed the following approximate conversion table:

Strength	Wt. per gal.		Amm. NH <sub>3</sub>	Twaddle	Sp. gr.	Wt. of gal.
oz.	oz.	lbs.	%	Degrees at 60°F	Water Basis	at 60°F lbs.
0	.000	.000	.00	0.0	1.	8.3328
1	.347	.0217	.2591	0.6	1.0025	8.356
2	.698	.0434	.5182	1.	1.005	8.377
4	1.393	.0863	1.0364	2	1.01	8.418
6	2.082	.1301	1.5546	3	1.015	8.460
8	2.786	.1735	2.0728	4	1.02	8.502
10	3.469	.2169	2.591	5	1.025	8.544
24	8.328	.5205	6.2184	12	1.06	8.835
28	9.726	.6079	7.2548	14	1.07	8.918
32	11.104	.6840	8.2912	16	1.08	9.002
36	12.492	.7807	9.3276	18	1.09	9.085
40	13.878	.8676	10.364	20	1.10	9.168
44	15.265	.9544	11.4004	22	1.11	9.253
48	16.654	1.0411	12.4368	24	1.12	9.336
52	18.041	1.1276	13.4732	26	1.13	9.420
56	19.429	1.2143	14.5096	28	1.14	9.503
60	20.816	1.3014	15.546	30	1.15	9.586
70	24.296	1.5179	18.137	35	1.175	9.795
80	27.755	1.7352	20.728	40	1.20	10.004

Printed or type written instructions, made as terse as clearness will allow, should be mounted near the still for ready reference. These instructions should include every step necessary in starting, operating and stopping the still—every valve or cock that is to be opened, closed or oiled, and when; the necessary pressure and temperature in the various parts of the still; the strength of liquors and lime water, and how much to introduce and when; the vital importance of keeping the crude liquor overflowing at the seal pot. Remember that, to a novice the still is a complex machine. You find that even your older men know very little about the real workings of it. So do not blame the retort-house men, if the operation is not entirely satisfactory for want of, what seems to you, a simple twist of the wrist.



Very exhaustive instructions for installing and operating a still are furnished with each machine by the manufacturer, or may be had for the asking. You are apt to follow these in a general way. The same may be said about construction.

The steam regulator can be profitably replaced by a plain globe valve with metal disc. The valve is more reliable, easily adjusted and cheaply repaired or replaced. Plain iron cocks are preferred to the high priced ammonia valves, for like reasons. Wrought iron pipe should supplant lead as far as possible—the lead to be used only where expansion requires it; tees or crosses, in place of plain ells, especially in the vent pipe, will facilitate steaming in case of salting. The old advice to steam out the whole still to dissolve the acid salt is absurd. A 12 ft. length of steam hose and a convenient steam opening will make it possible to relieve local salting in a few minutes, and without overheating the absorber.

The pipe to the concentrated liquor tank should be steamed about once a month to insure a free flow at all times.

It should not be necessary to take off a hand hole plate within a year to remove pitch or lime. Careful regulation of the tar-ammonia separator will almost exclude tar from the crude liquor tank. A few minutes hand pumping from the bottom of the tank before each distillation will remove the trace of tar that went over in suspension. A daily blow off from the bottom of the liming leg will keep the machine clear during the operation.

The present methods for injecting lime are far from satisfactory. A device whereby quick lime can be introduced directly into the leg at short intervals would be a decided improvement.

Many other points about the present construction and operation of ammonia plants are far from satisfactory. Then why should the machine be complex? Steam is an expensive necessary agent. Yet its energy is flagrantly dissipated from large uncovered radiating surfaces.

Perhaps, right here, you will be interested in some experimentally derived data on the quantity of steam used to distill crude liquor. For the sake of brevity, computations will be omitted and the results only, be given.

The method employed to obtain the value was by passing the steam through a standardized nozzle and computing the number of feet of flow per minute. Remember that the crude liquor was introduced in a sensibly heated state; otherwise the steam consumption would have been still greater.

Crude liquor distilled per minute	17.5 lbs.	
Steam supplied per minute	4.033 lbs.	
Heat units in 4.033 lbs. steam	4763.38	
Heat units used on 17.5 lbs. liquor	2173.30	
Heat units lost in still		2590.08
Heat units discharged with waste	333.07	
Heat units in concentrated liquor	259.87	592.94
		<hr/>
Heat units lost in radiation		1997.14

From these significant figures you gather that nearly half the heat supplied is dissipated through radiation.

Ammonia stills—stacks of cast iron laminae—are fit monuments to the engineering skill of the past 50 years. And it is a pretty compliment to the Gas Men of the corresponding period that they blew steam into these monuments and didn't know that they were operating a heating plant. And yet the ammonia still even in its present state of inefficiency is a paying asset.

For comparative data, take a 3000-ton plant. Assume an actual saving of 4.5 lbs. ammonia per ton carbonized, and a sale price of 7c per lb. f. o. b. cars; the gross returns would be \$945.00.

And the cost of making marketable ammonia would be:

Steam coal necessary for still only	\$ 90.00
Steam coal for pumps, lime, heat, etc., estim.	20.00
Interest and depreciation on \$3,000 @ 10%	300.00
Extra labor for cleaning, operating, etc.	150.00
Lime (2 lbs. per ton) 30 bbls. @ \$1.00	30.00
Repairs, renewals, changes, contingencies	40.00 630.00
	<hr/>
Yearly saving	\$315.00

The operation of the ammonia still requires, not only that all the ammonia be absorbed from the gas and the liquor carefully collected; that all leaks in tanks and still be hermetically repaired; that careful attention be given to every step in the running of the still proper. It calls for personal attention, tact, persistence, originality.

# PREVENTION OF ACCIDENTS

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*By N. D. McPHAIL, Aurora, Illinois*

The introduction of machinery into modern lines of employment brought many risks and hazards. At first little attention was given to the fact, many manufacturers attributing the increased number of accidents to the increased output, but time proved this to be a false view, as additional accidents meant an outlay for repairs and damages for killed or injured workmen; and a decrease in production, owing to the fact that the spirit of the workmen was affected, thereby reducing their efficiency and interest.

Once these conditions became apparent to the manufacturers they set about to correct them. At first they aimed to prevent accidents recurring; now they aim to prevent the first accident. Numerous methods have been tried with varying results, but the improvement in general conditions is marked, the loss of life and the destruction of property has been greatly reduced.

What can be done in the gas business to reduce the number of accidents? There is no doubt but what we take all ordinary precautions to prevent accidents, but accidents have happened and will happen again. What we most want to do is to devise some system by which improper and dangerous conditions can be brought to our attention and rules established by which these conditions can be improved.

Let us make a study of the accidents which have occurred and from these compile a set of rules that will prevent the same accidents occurring more than once; and if we have no record of the accidents that have occurred during the past few years, the best thing that can possibly be done is to have a record prepared and these accidents thoroughly discussed with the different managers and superintendents, and a set of rules prepared that will overcome the liability of these accidents recurring. If we have found a certain piece of machinery has been the cause of an accident, the men should be gathered together and something should be done to improve conditions so that an accident of a similar nature can not occur again.

In this way we would make an accident committee out of the superintendents and foremen employed by the Company. We would train them especially to use forethought and judgment and not ask their employees to go to work where there is any danger through loss of life or destruction of property.

Sometimes, however, there are causes where it is absolutely necessary that a man should assume some risk. In cases of this kind the employee should be given every possible safe-guard known to the Gas fraternity and be given every assistance possible in the way of help. He should be provided with the very best of tools, be provided with a respirator and in cases where a respirator can not be used, he should have an oxygen helmet and should never be allowed to work in a dangerous position alone, but should, at all times, have with him another employee who understands thoroughly the action of the gas and exactly what to do in case the operator should be overcome. This information should be taught him at the meetings of these committees and would do a great deal to reduce the number of accidents now occurring.

Accidents can be divided into two classes; accidents to life and accidents to property, and these again be subdivided, first, into accidents to the life of our employees and of the public, and second, accidents to the property of the company and to the property of the Public; and, in order to protect fully the life and property of the Company and the Public it is well to have a clearly defined set of rules drawn up to govern the actions of our employees and protect the public.

We are responsible to the Public for their safety inasmuch as we sell them an explosive commodity. They must be taught that gas when properly used is a great convenience, but when improperly used is very dangerous. A set of rules should be given to each customer who makes application for gas so that in case certain conditions arise where accidents may occur they can consult these rules and know exactly what to do under those conditions.

The fact of the matter is, the consumers of gas are so interested in their own safety that this set of rules would be memorized by every consumer on the mains. If these could be impressed upon the mind of the consumer such things as accidents from gas explosions of many kinds would be unknown. We get out a set of rules governing the conditions under which a meter will be set, how bills are collected, etc., but what gas company hands a consumer a set of rules as to what to do in case an accident occurs?

Further, we must protect our customers in the appliances we sell them. Very few gas users know the strong and weak points of appliances which they purchase. They can not see whether an appliance is safe or unsafe. We must sell appliances that will insure them the greatest measure of safety and we must connect these appliances in such a way that there is no danger of an accident occurring from a leak or from defective workmanship. In order to assure ourselves that connections are being made in this way no connection should be made that will not stand the pressure test. We should also insist on an inspection of all piping being made before making a meter connection. For example, a house may have used gas for years, the piping having been tested and found in good condition and yet something may have occurred that caused that piping to leak. Before the meter is set a test should be made and if the piping is not found absolutely tight we should refuse to connect the meter. This has been done in several cases and the customer, after the matter had been explained, was thoroughly satisfied and instructed the Company to repair the damaged piping at once and then make the connection.

We should also refuse to make any connections other than solid pipe connections, as a large percentage of the accidents occurring to the Public can be traced to the use of insecure hose connections. Gas hose should be sold only for the purpose of connecting reading lamps, flat irons and gas heaters but every one of these gas appliances should have no valve, thereby compelling the customer to turn off the gas at the fixture, thus preventing the pressure being left on the hose.

In case it is necessary, at any time, to discontinue the supply of gas on certain streets the customers on that certain line should be notified that the gas will be shut off for a given length of time, and they, in turn, should be asked to see that the gas has been turned off at all openings and appliances. Then as soon as the connection is again made the customers should be notified that the gas has been turned on. In this way possible accidents caused by the discontinuation of service will be prevented.

Another cause of accidents in certain classes of buildings is the prepayment meter. We are especially anxious to increase our sales and develop our business and in so doing have found an instrument that suits our purpose very admirably and allows us to reach a class of customers whose credit is so poor we could not accept the account with a regular meter. Special instructions should be issued every time one of these meters is put into use,

calling attention to the fact that care should be used in the handling of gas through a prepayment meter as the supply of gas is liable to be shut off at any time and before another coin is placed in the meter the consumer should see that all gas jets and appliances are shut off, thereby preventing any possible chance of an accident occurring.

In addition to the safeguarding of the lives of our customers it is also necessary that we protect their property. All openings made in the streets should be properly protected by danger signals during the day and by red lanterns during the night to prevent accidents arising from an open ditch.

All excavations made in the busy thoroughfares or the downtown streets should be protected by railings running completely around the excavation.

All service pipes laid should be thoroughly inspected for leaks and all stub services should be thoroughly tested before being capped and covered up. In addition, it is necessary that leakage gangs be kept continuously at work upon the streets to determine any escape of gas, which is not only on account of the loss of gas but also on account of the damage done to trees, shrubs and vegetation by a gas leak.

Our next care should be that of our own property. The gravest danger naturally arising around a gas works or gas main is from fire and still some gas works use the old gas torch in some parts of their works. It would be well to discontinue this and use electric lamps with vapor proof sockets with a switch outside of the building so that in case any serious accident occurred the lights can be turned on without the employees endangering themselves in any way. In case of gas having escaped through the works and one of these lamps exploding, the socket is still an absolute protection and there would be no danger from fire.

No matches should be used anywhere around a works but if it is absolutely necessary that matches should be used, nothing less reliable than a safety match should be allowed; and if there should be a frequent use for light a vesta battery could be used, thus doing away with that danger.

In addition to these safeguards it is well to have fire extinguishers easy of access in every part of the works. These fire extinguishers should be taken out and examined periodically, say at least every month, and the chemicals contained therein reduced to

a fine powder. If possible, a complete fire protection system should be installed in the works, and should be under easy control so as to be convenient in time of fire.

All holders and relief holders should be equipped with signal systems so that the height of the holder may be ascertained at any time without difficulty. The relief holder should be equipped so that an electric gong or steam whistle would warn the foreman that the holder was low a considerable time before the crown would cave in.

In cases of leaks around the works, men should never be allowed to look for a leak by fire. Soap and water is equally effective in locating leaks and has the advantage of being absolutely safe. This would also apply to men doing gas fitting.

As to the protection of the life of our employees, this is rather a difficult matter. The force of any gas company is made up of a large body of employees, each working more or less independently of the other and no set of rules can be devised that will govern the conditions as they exist in every situation. We have to warn employes, give them all the instruction possible, be very definite in requiring them to use extreme care and then leave them to their own resources, they, of course, being cautioned that they must follow religiously the general rules laid down. We must equip these employees with good tools and the means whereby they can keep them in good shape and we must expect them to obey instructions. In addition to this, if we should have an accident committee to whom all employees could make reports of accidents that occurred and of all the accidents that they anticipate, with the rules followed and the committee working vigorously, many accidents that might occur could be prevented.

In regard to protecting our works more thoroughly from accident, it would be well for the General Manager of a company to require a monthly inspection report from the Superintendent of Works, over his signature. The report would be similar to the following and you can readily see the effect it would have on insuring perfect inspection and cause the men to observe carefully the condition of all apparatus in and about the Works.

1. How many feet of good fire hose have you?
2. Rubber lined, or linen?
3. When was it last used?
4. In what condition was it?
5. Where and how is it kept?

6. Have you examined connections, couplings and nozzles, and is hose ready for immediate service for the prevention of fire?
7. Do you require any more and how much?
8. How many wet fire extinguishers have you?
9. Where are they located?
10. When were they last inspected?
11. How many dry fire extinguishers have you?
12. Where are they located?
13. Are they hung on stout supports so as to be easily pulled open?
14. When was the powder last examined to see that it is not caked?
15. How many water barrels have you?
16. Are they all full?
17. Where are they located?
18. Are buckets hung conveniently?
19. How many?
20. How far is the nearest fire alarm box?
21. Have you a key and where is it hung?
22. Have you any other safety devices? Describe fully.
23. Is purifying house kept locked at all times when not doing work there?
24. Where is the key kept?
25. When men are working there, are unauthorized workmen kept away?
26. Are all windows in the purifying house sound? If not, how many are broken?
27. Is Works regularly inspected at night, and by whom?
28. Are anti-smoking notices posted, and where?
29. Are electric lights in purifying house protected by safety globes and are all these in good condition?
30. When did you last look over the exposed electric wiring and what defects, if any, exist?
31. Is the whistle attachment to all relief holders in good working condition?
32. At what point in its descent does the holder operate the whistle?
33. Your steam boilers are numbered from left to right; place after each number the pressure up to which you understand it is insured and the pressure at which you know the safety valve is set.
34. How many ladders have you at the Works?
35. When were they inspected?



36. Are all stairs, all floorings and all railings in good condition?

37. When were they last inspected?

38. Do you use a protected guage glass?

39. What kind?

40. Are all tar wells protected by railings?

41. Have you a complete kit of tools?

42. If not, which tools are missing?

43. If tools are not in good shape note those needing repairs and those needing replacements.

44. What provision have you made to get workmen out of purifying boxes should they be overcome when emptying boxes?

45. Are you supplied with sufficient locks to lock valves when cleaning boilers?

46. Do you always use them?

47. Are all windows above the first floor properly protected with bars?

48. How many elevators have you?

49. Are they thoroughly protected with railings and gates, and are all counterweights properly boxed in?

50. When men are using the diamond point for cutting pipe, do they use a shield to prevent flying chips from doing damage?

51. What provision have you made in order that gas will not be turned into a purifying box while same is being cleaned?

52. Do you make a careful inspection of all manhole covers before changing purifying boxes?

53. Do you allow the use of any matches around your works?

The filling out of this report would necessitate a very thorough inspection of the entire works by the superintendent, and he would, at that time, feel that the responsibility for any accident rested upon him. We could also, at the conclusion of the report, leave a space asking for any suggestions he could make that would improve the safety of conditions at his plant, and, by this method, in a short time the chance for accidents would be practically eliminated.

A report similar to this could be prepared and sent to the Superintendent of the Shop and Fitting gang, also to the Street Superintendent, covering very carefully all cases where accidents are liable to occur in his work. This report, the same as the Works Superintendent's report, would require a thorough inspection and a thorough knowledge of what should be done to prevent accidents and would keep the shop and street superintendents on the lookout, at all times, for any trouble that might arise.

Although all possible care is taken and all these reports are properly turned in, insuring a thorough inspection, accidents will, unavoidably happen. Let us have an accident report giving all the details of the accident. Such a report as follows might be used, emphasizing the fact that we wish particular attention given to the cause of the accident, so that the same accident will not occur again.

### ACCIDENT REPORT For Managers and Superintendents

Date..... Time.....  
 Place .....  
 Cause .....  
 .....  
 .....  
 Nature of Injury .....  
 Name of Injured .....  
 Residence.....Occupation.....  
 By what Department Employed .....  
 Age..... Nationality.....  
 Names and Residences of all Witnesses.....  
 .....  
 Attending Physicians.....

Instructions: Visit scene of accident as soon as possible. Interview all persons who may know anything concerning same. Talk with injured person and get signed, written statement, if possible. In case of serious accident or injury have witnesses write statement if possible, in presence of witnesses. Get date and signature of witnesses to statements. If witnesses do not write statements write them yourself, but get signatures. Do not use this form for witnesses' statements. Attach statements to form and send immediately to General Manager.

In minor accidents or injuries, merely fill out blank but do not get written statements of witnesses. Report all Accidents or Injuries or possible claims for damages. Use tact and judgment.

Now, having prepared these Inspection and Accident reports each company should form an Accident Committee, consisting of the General Manager, and General Superintendents. This committee should meet at least once a month and go over very carefully all accident reports and all inspection reports received from the different superintendents during the month. Schemes should be devised whereby an accident that once occurred is not liable

to recur, and all new devices for safeguarding our workmen should be brought before this committee and the recommendations of this committee should be accepted and acted upon by the Company's management. A report of the proceedings of these meetings should be kept and distributed to all the workmen. They would see that an effort was being made to protect them in their work and would undoubtedly be more careful of themselves and of their fellow employees.

Workmen should be encouraged to send suggestions to this accident committee, these suggestions to be discussed very freely and report of the discussion returned to the different workmen.

Frequently we can receive suggestions from manufacturers that will be of benefit to us. We might insert on all orders the following clause: "This Company is especially anxious to protect its workmen and any new devices brought out for that purpose should be brought to our attention and same will be given our consideration when the purchase is being made." This would secure for us the co-operation of all manufacturers who are experts in their line and qualified fully to furnish valuable help.

"This method of procedure, if taken by gas companies, will reduce the number of accidents to a minimum. Some system of inspection and inspection reports can be established in even the smallest plants, and where a number of workmen are employed accident committees can be organized with good results. Even the most limited inspection will prove profitable. It will bring inquiry and investigation and wherever an error is found there will also be found reform and a striving for better things."

Before this subject is finished I wish to express publicly my thanks to Mr. Harrington, our President, and to Mr. J. P. Coghlan of San Francisco for the definite help and information I received from them in the preparation of the foregoing paper.

# THE UTILIZATION OF GAS FOR DOMESTIC PURPOSES IN SUBURBAN LOCALITIES

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*By LESTER PRICE, Highland Park, Ill.*

In undertaking to write a paper on the above subject, I confess somewhat to a feeling of reluctance; partially because the territory over which I have charge is too limited it seems to me to treat of the matter broadly, and partially because I fear there can be but little said in any event, that would prove new or of interest to this convention. It did occur to me, however, that as we were doing business in a district admittedly typical of its kind, perhaps some excuse could be found for a short paper that would show in a way, the extent and use that illuminating gas has been put to, in a few of the well known and growing suburbs that lie within our territory.

To go into a little history—The North Shore Gas Company, a corporation of Lake County, was organized in 1900, purchasing and acquiring the rights and property of the Old Waukegan Gas Company, rebuilding and improving same, and supplying that city with a modern and up-to-date service. To the south and bordering the lake for a distance of approximately 20 miles, lie the suburbs of Lake Bluff, Lake Forest, Ft. Sheridan, Highland Park, Glencoe and Winnetka, and rights having been obtained in these towns, the question of their supply was taken care of, by installing a compressor at the Waukegan plant, and running a high pressure pipe line through the district, tapping each town in the order named. As I am perhaps better qualified to speak of the territory lying south of Lake Forest, I shall for the purposes of this paper, confine myself principally to the largest and probably most typical of the suburbs.

Highland Park, with a population slightly less than 5,000 people, lies at a point on the lake about 12 miles south of Waukegan and 22 from Chicago; and like most of the towns along the north shore, has its east and west sides, with the finer and larger homes predominating on the lake shore side. Our first step, I believe,

after acquiring an ordinance in this city and commencing the installation of street mains, was to purchase a piece of land on the edge of the resident district, and start the erection of an attractive little office building. This work progressed so rapidly that by the time the street mains were in, the building was done and we were ready for business. The first service was laid on the 22nd day of April, 1901, and while we continued to make these house connections about as fast as they could be installed, we found there was a large element in the city that knew little or nothing regarding the value of gas as a cooking proposition. This class (mostly west siders) had to be reached in some way, so that our next step was to hire a well and favorably known expert to give cooking exhibitions, demonstrating the value and use of the gas range under all conditions. These exhibitions or demonstrations which were held for a week or more in our newly finished office building, attracted much attention, and showed very thoroughly what was possible to do with the modern gas range, in both plain and fancy cooking. This started the ball rolling for us in good shape, so that by the end of the year, our records showed 250 meters set and 150 gas ranges in operation, with an average bill per family on the east side, of 4,000 ft. per month, as against 2,200 ft. on the west side, the difference of course being due to the fact that the east siders were the first to buy ranges, and were the more liberal users of gas. Our general average per meter in use for this first year's business was 2900 ft. per month, and this average stood approximately at that figure for the following 2 years, although we had increased our meters set to 500, and had in operation at the end of 1903 some 300 gas ranges. But we were commencing now to install water heaters quite generally throughout the town, (although most of them, like the ranges were going to the east side.) The west siders were starting in on the double oven ranges, where heretofore, it was about equally divided between single oven stoves and two burner hot plates; we had besides gone quite extensively into house piping, so that we were gradually getting into a position where a showing could be made.

At the close of 1905, we had to our credit 850 meters set, 400 gas ranges and 70 water heaters in use, and while we had increased our meters set over the previous 2 years some 70 per cent, we had as a matter of fact more than doubled our output. The following five years showed a steady gain in nearly all kinds of appliances. The city was growing fast and each gas range installed became so to speak, a solicitor for an other. The double oven range was fast replacing the single oven, and the cabinets the double ovens, (I

will say here that I have never been in favor of the small oven range, and with a very few exceptions I have allowed nothing on the floor less than 18 inches. This position I took from the start, so that in my territory at least, there has been little or no demand for the smaller sizes.) Water back ranges are also practically obsolete in my territory, the detached heater of the upright type, with its advantages of being placed close to the boiler and out of the way, having almost entirely replaced them. That much abused piece of machinery—the automatic water heater—was gradually finding its way into some of our best homes, and wherever they could be made to “stick,” increasing the gas bill from 80 to 100 per cent. But just a word here in connection with this heater. You will notice I qualified the statement by saying, “wherever they could be made to stick.” Now unfortunately we have not been able to make them all “stick,” and this was due partially to extravagance on the part of the consumer, and partially to misrepresentations on the part of agents selling this type of heater. I found that in a small square house where the water runs were short, they were most efficient. In the large houses, particularly the long houses, where the water runs exceeded 85 or 90 feet, we invariably looked for trouble; for apparently hot water could not be instantly and economically supplied through water runs of extended lengths, and unless the trouble could be overcome by placing the heater well toward the middle of the house, the only other remedy seemed to lie in the installation of two heaters, which their first cost practically prohibited. I found that in some places, agents were installing these heaters almost regardless of conditions and making the most absurd claims in reference to their cost of operation. If circulation was imperfect or lacking, it was, in some cases, remedied by installing a heater of the Storage or Multicoil type, which was another feature that gave trouble, because this method of installation, while it operated to give hot water instantly, kept the meter working overtime, and adding anywhere from 25 to 40 per cent to the cost of getting the hot water. Faulty connections on the part of plumbers, who did not seem to know the difference between pressure and volume, also gave us trouble; all of which helped to create more or less dissatisfaction, and so, as before mentioned, a few of them did not “stick.”

I believe, nevertheless, the automatic heater has come to stay. It is a field that seems to me capable of much developement; but the question of their installation, care and maintenance, I am satisfied must sooner or later be undertaken by the Gas Companies themselves, just as we are now in the habit of doing with ranges and other appliances.

The recent government census of Highland Park and its immediate surroundings gave a population of a little more than 5,000 people. Our own canvass of the city (just finished) showed exactly 1,150 houses, or an average household of about 4.5 people, against which, we had at the close of the year 1910, 1202 meters set, 250 water heaters and 950 gas ranges installed. Dissecting our records and using the above figures as a basis, I get the following results:

Population .....	5200
Number of houses or families.....	1150
Meters set .....	1202
Gas ranges installed.....	950
Water heaters installed.....	250
Gas sales for 1910.....	42,000,000 ft.
Average monthly bill per range in use (east side).....	6400 ft.
Average monthly bill per range in use (west side) .....	3043 ft.
Average monthly bill per meter in use (both sides) .....	3510 ft.
Total sales per year per capita....	8077 ft.

Figuring gas at \$1.00 per thousand and taking the estimate of 4.5 people to the average household, we find that it costs the east sider to do his cooking just exactly \$1.42 per month for each member of the family, as against 68 cents on the west side, or a general average over the entire town of about 80 cents. Further analyzing our records, we find that if a water heater is used, this general average is increased to \$1.05, and if in addition to that, the laundry work is done, to \$1.45 per month for each member of the family. (I might add here that these figures are based on our total output, but as we are probably selling from 5 to 10 per cent for light, the averages noted above should be corrected or reduced to that extent.)

Speaking of some of the other suburbs—Lake Forest to the north, with a population of 3,200 people and a wealthier town than Highland Park, has a much higher average bill, I believe it is over 4,000 ft. per meter set. Winnetka and Glencoe to the south, with a population of 5,100 people, averages very closely to Highland Park, and in this district which is yet in a state of first development, we have 1,200 meters set and about 800 gas ranges in operation, with a total output for 1910 almost identical with that of Highland Park. Combining the two districts of Highland Park and Winnetka, we have:

Population .....	10300
Number of houses or families.....	2378
Meters set .....	2402
Gas ranges installed .....	1750
Water heaters installed.....	400
Gas sales for 1910.....	83000000 ft.
Average monthly bill per range in use .....	3900 ft.
Average monthly bill per meter in use .....	3500 ft.
Total sales per year per capita....	8058 ft.

I think you will agree with me that these figures are above the average, and are probably not to be found except in well to do suburban localities, where the people as a class have been accustomed to the use of gas and in the majority of cases, use it almost altogether for cooking.

Now, in conclusion, I do not suppose that the class of patrons we find on the North Shore, are any different or require any different treatment than is found in any other place of similar conditions, but just a word regarding our side of it. It has been said that public utility corporations are public servants, and this is probably true of gas companies as of any other corporation. In my district we are doing business with 90 per cent of the people, practically 9 out of 10 families using gas, and as we have a great many customers whose bills are far above the average, (some of them from \$20.00 to \$30.00 per month) this naturally means "complaints." We are not, I regret to say, overburdened with testimonials or letters of thanks for good service, although we are entitled to them once and a while, but the "kicks" continue to come in promptly on schedule time. In dealing with our customers, most of them successful and well to do business men, considerable tact is necessary at times to hold and keep them satisfied; and it would be poor business indeed (if pleasant relationship counts for anything at all) to deal with them on any lines except those of the broadest policy. Refusals on their part to pay bills which they consider exorbitant or unreasonable can not be met by the threat to "shut off the gas," drastic treatment is not to be thought of, but a little forbearance and courteous attention on our part usually brings a check from them before the gas bill is very old. We treat every complaint, however trivial, as fair and legitimate on the part of the consumer. We do not argue or enter into any controversy over a disputed bill; if it can be shown to the customer at the time wherein he is wrong, it is done so, quietly and politely, otherwise



a promise is made that the matter will be thoroughly investigated. But what he demands and expects, first, last and at all times, is prompt attention, and this, with a little common courtesy and patience, has enabled us to get along fairly well together.

# INDUSTRIAL APPLICATION OF GAS

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*By M. J. DEWEY, Cairo, Illinois*

The term "Industrial Gas" as I shall use it means: Gas used directly in the procedure of commercial or manufacturing industry. Consequently the subject of lighting in any way will not be discussed. Therefore, to assume that this paper will cover fully all points that could come under its title would be absurd, but if you will permit me, we will call it instead, a Synopsis of the Industrial Application of Gas. The use of gas for heat as a part of one's business is confined to our own time, which means that a new science is in its infancy. Let me emphasize the word science, for such it is, as accurate, as clearly defined as chemistry, physics or astronomy. It deals with the combustion of gases to produce power, light and heat, and to attain its ends with the greatest conservation of material. It endeavors to convey to the minds of its students that the use of coal and other crude fuels were not intended for small units, but that these materials should be refined by a great single unit and the finished product be delivered to its ultimate consumer.

Before going too far into the details and methods of using gas industrially, I wish to touch lightly upon the theory of combustion.

In order that we may collect all of the heat that is in the gas, we must oxidize all of the material in the gas into non-combustible gases. And to allow the out-going waste gases to depart at the same temperature of the gas before it reaches the burner. That means that all the gas must be oxidized to carbon dioxide and water and lowered to the inlet gas temperature, and to have a perfect appliance all of the heat must be directed upon and absorbed by the object to be heated. Again the energy in the gas must be delivered as heat energy and not as light energy. Therefore the efficient burning of gas resolves itself into an infinite number of explosions of the proper mixture of oxygen and gas. (The oxygen, of course, being that taken from the air.

In our study of chemistry and metallurgy we were taught that the flame of the blow pipe could be made reducing, or oxidizing,

and this principle is used in many industrial gas appliances. For instance, when steel is subjected to the direct gas flame for the purpose of tempering or annealing, it should be placed in the reducing flame (one that has not an excess of oxygen.) In order that the stock be not wasted and carbon therein burn to carbon dioxide. It is therefore evident that a gas forge, tempering furnace or annealing furnace, properly adjusted, will improve the stock rather than to damage it. Again if it is desired, the oxidizing flame can be used to place a proper color on the finished work.

In the case of heating rooms, of which I shall speak more fully later, if the heat be driven into the room, drawn from an oxidizing flame, the people, though breathing some waste gases will also be breathing what is termed nascent oxygen, which is very invigorating.

Now the burning of gas to obtain heat is accomplished by two distinct methods. One, the mixing of air and gas before it reaches the burner by a jet of gas drawing in air from openings properly constructed upon the siphon principle, the other, the mixing of gas and air by a mechanical process.

The first type of burner is called the atmospheric type and the second, the blast type. Their scientific difference lies in the fact that the former burns gas in an atmosphere of air and the latter burns air in an atmosphere of gas. Now the explosive mixture of air and gas lies approximately between 8% gas and 92% air and 25% gas and 75% air. In the atmospheric type we are able only to burn gas and air when the percentage of gas is a little greater than will form a perfect mixture, while in the blast type we are able to even go too far and get an excess of air which also tends to destroy available heat. The blast type of burner can be used successfully even though the gas pressure is very low, and by the use of the constant pressure regulator, set at the outlet of the meter at the minimum pressure shown by the recording chart, we are able to state to the consumer that his conditions are continually the same. This proves a help not only to the user, but also to the maintenance department which can know that any fault must certainly be local.

I had intended to give a little discussion in this paper concerning the various types of industrial appliances, but the information can be so easily obtained elsewhere that I will limit it to a few semi-original and successful ones that are not widely known.

Heating small theatres would at first seem absurd when the question of gas for fuel is suggested, but the problem has been

solved in one fairly large theatre and can be in every other small vaudeville or picture house. By placing a blast pipe burner having a capacity of five or six hundred feet per hour so that the flame is drawn into a larger circulating fan which leads through heating pipes to registers placed in aisles of the theatres and the air from the room be drawn through openings near the floor back to the room that contains the appliance, one is able to heat the room comfortably in a surprisingly few minutes, and it is only necessary for a very low rate of flow of gas to be used to keep it in this condition until the close of the performance. It is simply a matter of closing all openings to the outside to make this method an economical one. The advantage of this device is that the heating process need not start until about ten minutes before the doors open; there is no cold storage room, no smoke, no smell and practically no need of an attendant. Again, the stage and dressing rooms can by a little studying, be heated at the same time and with the same burner. I do not mean that this principle can only be used by theatres, but any place where occasional heat is required, such as Churches, Assembly Halls and many other meeting places.

### THE HAM BOILER

Not long ago I had occasion to install a ham boiler and as I was detailed to design the appliance, I immediately began thinking. The receptacle for the hams was rectangular, being 8 feet long, 3½ feet wide and about 30 inches deep. The sides were double, having a one-inch air space, and vent holes at the top, and the outside jacket extended 8 inches below the bottom of the tank. 1½ inches below the bottom two drilled 1½ inch pipe burners run the entire length, and through these burners are connected a single suction tee, gas and a direct connected one-tenth H. P. A. C. fan blower. As will be noted by the sketch an angle valve is placed between the manifold pipe and the second burner, in order that the pressure on both can be made alike and when but one burner is needed the other one can be turned off. This proved very efficient and has the distinct advantage of materially reducing shrinkage in the weight of the hams, and also permitting them to retain their tasty juices that would otherwise be boiled out, due to varying temperatures. The same device proved beneficial in scalding chickens. On testing this appliance we found that we could raise one hundred and seventy-five gallons of water from 78 degrees to 198 degrees in 38 minutes with the gas burning at the rate of 420 feet per hour, or an efficiency of a little better of 83%.

In each of these two installations a type is represented which has been barely introduced and yet are embryos of what may be a great industrial field.

You have, no doubt, already noted that wherever there is a chance I am partial to the blast type of burner. I believe that a great many dissatisfied customers who have had atmospheric installations have been made boosters by changing them over to the blast type.

Now into this class comes a subdivision. The positive pressure blower type and the fan blower type. The fan blower will hold its pressure and velocity fairly well, if there is a very short run of straight pipe and one or not more than two burners connected, but where there are many small burners or where more than one installation is supplied by the same blower it is far more satisfactory to use the positive pressure blower. The advantages of the fan blower are: low first cost, low power cost and simple operation, while the advantage of the positive pressure blower are perfect adjustment, adaptability to any number of burners and appliances up to its capacity and also the advantage of locating it at a distance from the burner.

In deciding just what methods shall be employed in installing an appliance great care must be taken, and unless it is something extraordinary, do not do any experimenting with your customer. It has very damaging effects; it burns his gas and loses his confidence in the ability of the Company's employees. An industrial man, therefore must have many and varied requirements. He must be familiar with all methods of manufacture of the different customers and prospective customers' plants, he must have good address, good literary and mechanical ability, in fact he must be an all-round gas man.

When the Industrial Fuel expert has gained the confidence of his prospective customer, he has the installation practically sold, but should he fail in this one point the position is hopeless. It therefore behooves a Company to secure a good industrial man and back him and boost him to all their customers in every way possible.

Although it may seem like time and money wasted, it is wise to educate all industrial consumers regarding the combustion of gas and its properties in general, also to make the buyer realize that although gas is an economical fuel it is very expensive when waste and negligence is permitted; that he will take possession of an installation that is capable of fine adjustment which has been

built exactly right by experts who have specialized in that particular line. Let him realize that his appliance is one that is thoroughly modern and can do its work faithfully and accurately because it has reached its state of perfection through long and carefully conducted experiments. This results in the consumers being converted to your way of thinking, and eventually places an installation in nearly every place you think one can be successfully used. An industrial salesman must spend plenty of time with his prospective customer, and, if he knows his business, he will be able to guarantee perfect satisfaction to his customer, no matter what the proposition may be.

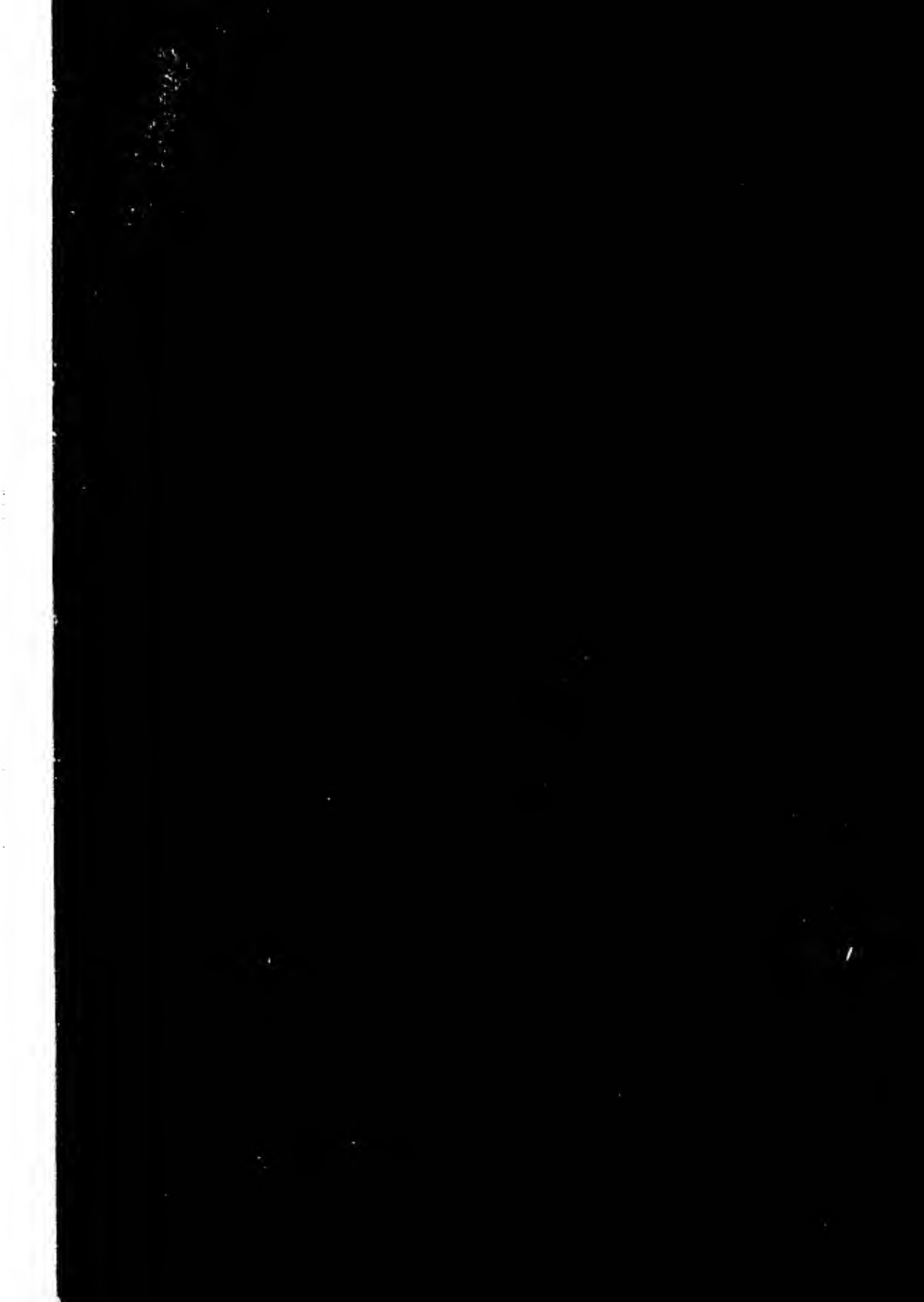
In conclusion I wish to impress upon the mind of the reader that the industrial department, though thoroughly scientific, requires one thing more than anything else, and that one thing is good, hard common sense behind it. If each company had an industrial man that was blessed with this requirement we would soon see great progress in the industrial field. We would soon hear of numberless large installations that with our present knowledge we would fear to attempt.

This article is written in the hope that the managers and superintendents here represented may push their industrial work, and that the industrial men themselves may add a little more energy in their work to perfect this, our new science.











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*Thesis for Ch. E. at A.D. T.*

*Churton S. Heath*

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